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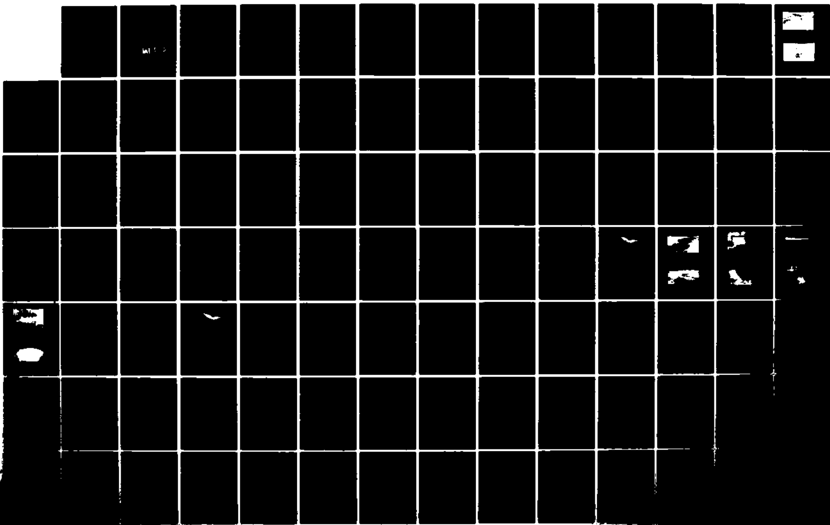

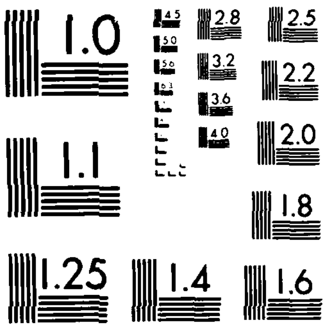

MICROCOPY RESOLUTION TEST CHART
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MERRIMACK RIVER BASIN
NEW IPSWICH, NEW HAMPSHIRE

SOUHEGAN RIVER WATERSHED
DAM NO. 35

NH 00435

NHWRB 175.21

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

AUGUST 1979

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

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Merrimack Rwver Basin
New Ipswich New Hampshire
West Branch Souhegan River

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The dam isan earth embankment 1209 ft. long and 30 ft. high. The dam is intermediate in size with a high hazard potential. THe test flood is the PMF. The dam is in good condition at thepresent time. There are various remedial measures which must be undertaken by the owner.

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF:

NEDED

SEP 24 1979

Honorable Hugh J. Gallen
Governor of the State of New Hampshire
State House
Concord, New Hampshire 03301

Dear Governor Gallen:

I am forwarding to you a copy of the Souhegan River Watershed Dam No. 35 Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Water Resources Board, the cooperating agency for the State of New Hampshire and owner of the project.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Water Resources Board for your cooperation in carrying out this program.

Sincerely,

Max B. Scheider

MAX B. SCHEIDER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

SOUHEGAN RIVER WATERSHED DAM NO. 35
NH 00435

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MERRIMACK RIVER BASIN
HILLSBOROUGH COUNTY, NEW HAMPSHIRE

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

PHASE I REPORT

Identification No.: NH 00435
NHWRB No.: 175.21
Name of Dam: SOUHEGAN RIVER WATERSHED DAM NO. 35
Town: New Ipswich
County and State: Hillsborough County, New Hampshire
Stream: West Branch Souhegan River
Date of Inspection: May 14, 1979

BRIEF ASSESSMENT

The Souhegan River Watershed Dam No. 35 ~~is~~ located on the West Branch of the Souhegan River approximately 3/8 of a mile upstream of Smithville, New Hampshire. The dam is an earth embankment 1209 f~~ee~~t. long and 30 f~~ee~~t. high with a drop inlet service spillway structure and a 36 inch outlet conduit. An emergency spillway 255 f~~ee~~t. wide is cut into the left abutment.

The dam is owned by the New Hampshire Water Resources Board. It was designed by the Soil Conservation Service for the purpose of flood protection in the Souhegan River Watershed.

The drainage area of the dam covers 6.3 square miles and is made up primarily of rolling woodland. The dam impounds only 65 acre-feet at low stage but has a maximum impoundment of 1787 acre-feet. The dam is INTERMEDIATE in size and its hazard classification is HIGH since significant property damage and loss of life could result in the event of a dam failure.

The test flood for this dam is the Probable Maximum Flood. The peak inflow for this flood is 17,160 cfs (2,724 cfs). Because of storage, the resulting peak discharge is 12,670 cfs compared to a spillway capacity of 13,061 cfs. The water surface would be at elevation 1,089.9 feet (MSL) or 0.1 feet below the top of the dam for this flood.

The dam is in GOOD condition at the present time. Remedial measures to be undertaken by the owner include; monitoring the seepage through the headwall, and, under high reservoir conditions, through the right toe drain; filling in animal burrows; mowing of slopes; removing shrubs or saplings and filling holes left by their roots; removing debris from trash racks; operating

A

the pond drain gate as part of the annual inspection procedure, and developing a formal written emergency flood warning system for the dam. No conditions were observed which warrant the attention of a registered engineer.

The remedial measures outlined above should be implemented within two years of receipt of this report by the owner, however, the program of annual technical inspections should be continued.

William S. Zoino
N.H. Registration 3226

Nicholas A. Campagna, Jr.
California Registration 21006

This Phase I Inspection Report on Souhegan River Watershed Dam, No. 35 has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgement and practice, and is hereby submitted for approval.

Joseph A. McElroy

JOSEPH A. MCELROY, MEMBER
Foundation & Materials Branch
Engineering Division

Carney M. Terzian

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

Joseph W. Finegan, Jr.

JOSEPH W. FINEGAN, JR., CHAIRMAN
Chief, Reservoir Control Center
Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Fryar

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the Test Flood should not be interpreted as necessarily posing a highly inadequate condition. The Test Flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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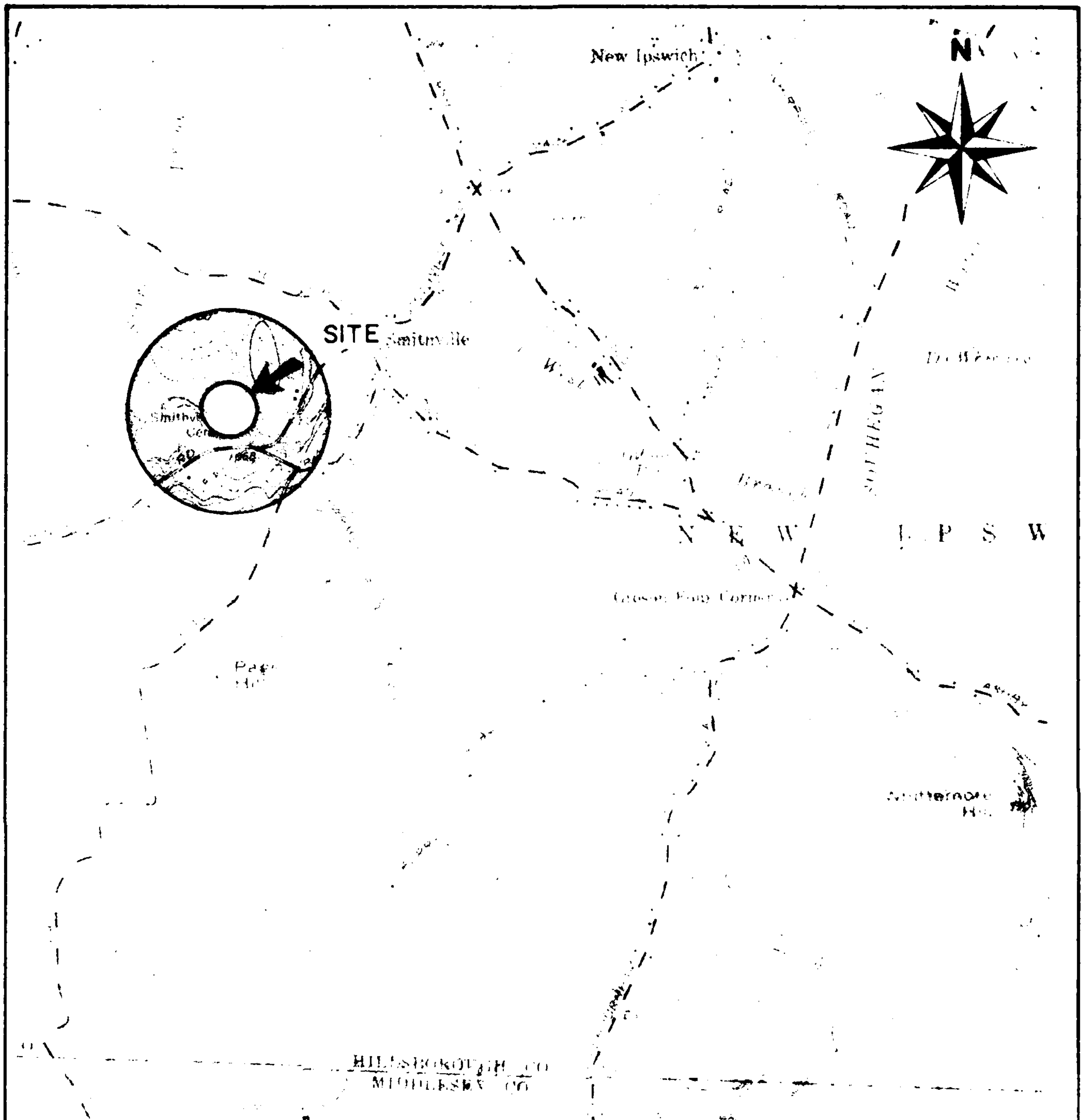
Overview photo from right abutment

Overview photo from left abutment



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FROM: USGS ASHBY & ASHBURNHAM MASS. - N.H QUADRANGLE MAPS

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC GEOTECHNICAL CONSULTANTS NEWTON UPPER FALLS, MASS.	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCUS PLAN

FILE No.2327

SOUHEGAN RIVER WATER SHED
DAM No. 35

NEW HAMPSHIRE

			SCALE	AS NOTED
			DATE	MAY 1979

PHASE I INSPECTION REPORT

SOUHEGAN RIVER WATERSHED DAM NO. 35

SECTION 1

PROJECT INFORMATION

1.1 General

(a) Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States, The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Goldberg, Zoino, Dunnicliff & Associates, Inc. (GZD) has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed were issued to GZD under a letter of March 30, 1979 from Colonel John P. Chandler, Corps of Engineers. Contract No. DACW 33-79-C-0058 has been assigned by the Corps of Engineers for this work.

(b) Purpose

1) Perform technical inspection and evaluation of non-federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-federal interests.

2) Encourage and prepare the states to initiate quickly effective dam safety programs for non-federal dams.

3) Update, verify, and complete the National Inventory of Dams.

(c) Scope

The program provides for the inspection of non-federal dams in the high hazard potential category based upon location of the dams, and those dams in the significant hazard potential category believed to represent an immediate danger based on condition of the dams.

1.2 Description of Project

(a) Location

The Souhegan River Watershed Dam No. 35 is located on the West Branch of the Souhegan River approximately 3/8 of a mile upstream of Smithville, New Hampshire. It can be reached from Binney Hill Road which intersects Smithville Road which intersects State Route 123A in New Ipswich, New Hampshire. The dam is shown on USGS, Ashby-MA, quadrangle at approximately coordinates N 42° 44.1', W 71° 52.9'. (See location map on page v). Figure 1 of Appendix B is a site plan for this dam.

(b) Description of Dam and Appurtenances

The dam consists of an earth embankment with an earthfill cutoff trench below the embankment, a principal spillway with a reinforced concrete riser and outlet pipe, and an emergency spillway located at the left abutment. The total length of the dam is 1464 feet, of which 255 feet is the emergency spillway.

1) Embankment (See pgs. B-3, 4 & 7)

The embankment is made up primarily of silty, clayey sand (SC-SM). It is 1,209 feet long with a 30 degree bend approximately 600 feet from the right abutment and is a maximum of 30 feet high. The upstream slope is 3.5 horizontal to 1 vertical: the downstream slope is 3 horizontal to 1 vertical: and the width of the crest is 14 feet.

Beneath the embankment is an earthfill cutoff trench which is 12 feet wide at the bottom. According to available plans, it is constructed of the same material as the embankment. The cut-off trench was designed to extend through sand and gravel layers to underlying, less permeable soil.

The dam is founded in glacial till and outwash at the left abutment. In the center section it is founded in alluvium made up of stratified fine grained soil. The right abutment and portions of the center section are founded in a deep kame terrace of clean sand and gravel.

2) Principal Spillway (See pgs. B-6 & 8)

The principal spillway consists of a reinforced concrete drop inlet structure with a sluice gate controlled inlet pipe and two uncontrolled orifice inlets, a 36 inch outlet pipe supported on a concrete cradle, and an impact basin.

The riser structure is 16 feet high and 11 feet wide normal to the axis of the dam. It is 5 feet long parallel to the embankment and flares to 17 feet long at the top. The walls of the structure are 12 inches thick and the top slab is 8 inches thick.

At the base of the structure is a 24 inch diameter, vertical lift, sluice gate inlet which is controlled by a wheel operated bench stand with a rising stem. A 24 inch diameter, asphalt coated, corrugated metal pipe extends 10 feet upstream from the left gate into the impoundment pool. Plans indicate a reinforced concrete inlet structure at the upstream end of this pipe which is protected by a trash rack of painted steel angle sections placed horizontally across the opening.

The "low stage inlet" is an uncontrolled opening approximately 4.5 feet above the sluice gate invert. It is 3 feet wide and 1 foot 10 inches high and is located in the upstream face of the riser structure. The water flows over this orifice and drops into the riser structure. It is protected by a trash rack assembly approximately 7 feet high and 3 feet, 9 inches wide. This assembly is fabricated from painted steel angle sections.

The "high stage inlet" consists of two openings approximately 13.3 feet above the sluice gate invert. They are 9 feet wide and 1.5 feet high and are located in the left and right sides of the flared portion of the riser structure. They are protected by a galvanized steel grating 10 feet long and 25 inches high placed in front of each high stage opening. A 30 inch diameter manhole permits access into the riser structure.

The riser structure is drained by a 36 inch diameter reinforced concrete pressure pipe. It is approximately 161 feet long and drops approximately one foot over that length. The pipe penetrates the downstream side of the riser structure and the earth embankment, and is supported by an 8 inch concrete cradle within the embankment. Plans indicate 5 concrete anti-seep collars cast around the pipe within the embankment.

The pipe outlets into an impact basin constructed of reinforced concrete. This structure is similar to that outlined in "Design of Small Dams," Chapter VIII, Section E as printed by the U.S. Department of the Interior, Bureau of Reclamation.

3) Emergency Spillway (See pgs. B-3 & 4)

The emergency spillway was excavated in the left abutment. It curves to the right around the embankment and is 255 feet wide at the control section. It is approximately 700 feet long and lies approximately 7 feet below the top of the embankment. The side slopes are 2 horizontal to 1 vertical.

4) Foundation and Embankment Drainage (See pg. B-5)

Toe drains extend from 115 feet to the left of the outlet to 666 feet to the right of the outlet (station 11 + 50 to station 19 + 31). These drains consist of a 4 foot wide trench drain of clean sand containing a 12 inch diameter, perforated, bituminous coated, corrugated metal pipe which outlets into the impact basin.

(c) Size Classification

The dam's maximum impoundment of 1,787 acre feet and height of 30 feet place it in the INTERMEDIATE size category according to the Corps of Engineers' Recommended Guidelines.

(d) Hazard Potential Classification

The hazard potential classification for this dam is HIGH because of the significant economic losses and potential for loss of life downstream in the event of dam failure. Section 5 of this report presents more detailed discussion of the hazard potential.

(e) Ownership

The dam is owned by the New Hampshire Water Resources Board, 37 Pleasant Street, Concord, New Hampshire 03301. They can be reached by telephone at area code 603-271-3406.

(f) Operator

The operation of the dam is controlled by the New Hampshire Water Resources Board. Key officials are as follows:

George McGee, Chairman
Vernon Knowlton, Chief Engineer
Donald Rapoza, Assistant Chief Engineer

The Board's telephone number is 603-271-3406. Alternatively, the Board can be reached through the state capital at 603-271-1110.

(g) Purpose of the Dam

The purpose of the dam is to reduce downstream flooding by providing temporary storage for the runoff from 4026 acres of watershed. This temporary storage is released through the low and high stage inlets of the principal spillway.

(h) Design and Construction History

The dam was designed by the U.S. Department of Agriculture, Soil Conservation Service in conjunction with the New Hampshire Water Resources Board. It was completed in 1965.

(i) Normal Operating Procedure

The dam is self regulating. The pond 'rain gate is operated as part of infrequent maintenance checks.

1.3 Pertinent Data

(a) Drainage Area

The drainage area for this dam covers 6.3 square miles (4026 acres). It is made up primarily of rolling woodland with some pasture and minor development.

(b) Discharge at Damsite

1) Outlet Works

Normal discharge at the site is through the 36 inch diameter outlet pipe. In the event of severe flooding water would flow over the emergency spillway. The invert of the low stage orifice is at elevation 1067.0 feet (MSL). The invert of the high stage orifice is at elevation 1075.8 feet (MSL).

2) Maximum Known Flood

There is no data available for the maximum known flood at this damsite.

3) Ungated Spillway Capacity at Top of Dam

The capacity of the principal spillway with the reservoir at top of dam elevation (1090 feet MSL) is 161 cfs. The capacity of the emergency spillway is 12,900 cfs at this level.

4) Ungated Spillway Capacity at Test Flood

The capacity of the principal spillway with the reservoir at test flood elevation (1089.9 feet MSL) is 159 cfs. The capacity of the emergency spillway is 12,511 cfs at this level.

5) Gated Spillway Capacity at Normal Pool

There are no gated spillways. The gated pond drain inlet is normally closed.

6) Gated Spillway Capacity at Test Flood

As stated previously, there are no gated spillways.

7) Total Spillway Capacity at Test Flood

The total spillway capacity at test flood elevation (1089.9 feet MSL) is 12,670 cfs.

8) Project Discharge at Test Flood

The total project discharge at test flood elevation (1089.9 feet MSL) is 12,670 cfs.

(c) Elevation (feet above MSL)

1) Streambed at centerline of dam: 1056 ±

2) Maximum tailwater: Unknown (1062.0 = normal)

3) Upstream portal invert diversion tunnel: not applicable

4) Normal pool: 1067.0

5) Full flood control pool: 1083.0

6) Spillway crest:

a) Pond drain inlet: 1062.5

b) Low stage inlet: 1067.0

c) High stage inlet: 1075.8

d) Emergency spillway: 1083.0

7) Design surcharge: 1085.4

8) Top dam: 1090.0

9) Test flood design surcharge: 1089.9

(d) Reservoir

1) Length of maximum pool: 4,400 ± ft.

2) Length of normal pool: 1,500 ± ft.

3) Length of flood control pool: 4,400 ± ft.

(e) Storage (acre feet)

1) Normal pool: 65.0

2) Flood control pool: 933

3) Spillway crest Pool:

a) Low stage inlet: 65

b) High stage inlet: 382

c) Emergency spillway: 933

4) Top of dam: 1,787

5) Test flood pool: 1,773

(f) Reservoir Surface (acres)

1) Normal pool: 23

2) Flood control pool: 98

3) Spillway crest pool:

a) Low stage inlet: 23

b) High stage inlet: 54

c) Emergency spillway: 98

4) Test Flood: 144

5) Top of dam: 144.6

(g) Dam

1) Type: Earth embankment

2) Length: 1,209 ft.

3) Height: 30 ft.

4) Top width: 14 ft.

5) Side slopes: Upstream: 3.5 to 1
Downstream: 3 to 1

6) Zoning: Homogeneous, semi-pervious, silty, clayey sand

7) Impervious core: None

8) Cutoff: 12 ft. wide, earthfill

9) Grout curtain: None

(h) Diversion and Regulating Tunnel

Not applicable

(i) Spillways

1) Type:

a) Principal spillway: Reinforced concrete Drop Inlet

b) Emergency spillway: Grass covered earth channel cut in left abutment

2) Length of Weir:

a) Pond drain inlet: 24 inch diameter pipe

b) Low stage inlet: 3 ft.

c) High stage inlet: 18 ft.

d) Emergency spillway: 255 ft.

3) Crest elevation (Ft. above MSL)

a) Pond drain inlet : 1062.5

b) Low stage inlet : 1067.0

c) High stage inlet : 1075.8

d) Emergency spillway : 1083.0

4) Gates: 24 inch vertical lift sluice gate on pond drain inlet

5) Upstream channel: Reservoir

6) Downstream channel: Narrow channel leading directly into the pond of another dam

(j) Regulating Outlet

The only regulating outlet is a 24 inch diameter pipe controlled by a wheel operated sluice gate. The pipe invert is at elevation 1062.5 feet (MSL). The purpose of this outlet is pond drainage, and it is normally closed.

SECTION 2 - ENGINEERING DATA

2.1 Design Data

Among other design data available from the Soil Conservation Service are hydrologic and hydraulic computations, structural computations, a geological report, soil laboratory test results, and slope stability analysis computations. This information was used extensively in the computations presented in Section 5 and Appendix D of this report.

2.2 Construction Data

"As built" plans are available for this dam and show good agreement with the design plans and the visual inspection.

2.3 Operational Data

No operational data is available as the dam is self regulating.

2.4 Evaluation of Data

(a) Availability

Sufficient data is available to permit an evaluation of the dam when combined with findings of the visual inspection.

(b) Adequacy

There is sufficient design and construction data to permit an asssessment of dam safety when combined with the visual inspection, past performance, and sound engineering judgment.

(c) Validity

Since the observations of the inspection team generally confirm the available data, a satisfactory evaluation for validity is indicated.

SECTION 3 - VISUAL INSPECTION

3.1 Findings

(a) General

The Souhegan River Watershed Dam No. 35 is in GOOD condition at the present time.

(b) Dam

1) Earth Embankment (See Photos #1, 2, 6 & 7)

Small animal burrows were found in the downstream slope, small saplings were growing in the right downstream slope, and tire ruts 6 to 8 inches deep were found in the right upstream slope. Some erosion from wave action has occurred on the upstream slope to the right of the riser structure. This erosion is 4 to 6 inches deep. The slope is not protected by rip rap.

The toe drains were functioning with the left toe drain discharging approximately two gallons per minute and the right toe drain discharging approximately fifty gallons per minute. The discharge is clear.

During the design phase, estimates of water loss were made assuming water surface at elevation 1067 feet (MSL). These estimates predict the flow in the right toe drain to be approximately 15 gallons per minute. The present flows are not excessive but are higher than originally predicted.

2) Emergency Spillway (See Photo #5)

The emergency spillway is in good condition. There are wet spots in the channel but these are caused by natural groundwater.

(c) Appurtenant Structure

1) Drop Inlet Service Spillway Structure (See Photos # 3 & 4

This structure was observed from the embankment since the ladder was too short to permit access to the structure.

The structure is in good condition with no evidence of spalling, cracking, or efflorescence. The sluice gate bench stand is in good condition. The hand wheel has been removed from the site to

prevent unauthorized use. The trash racks are in good condition, however, a considerable amount of debris, including tree stumps, is entangled at the low stage inlet.

2) Pond Drain Inlet Pipe

At the time of inspection the 24 inch pond drain inlet pipe was completely submerged and could not be observed.

3) Outlet Conduit (See Photo #10)

The downstream end of this conduit is in good condition with the exception that the preformed joint filler between the outside wall of the pipe and the impact basin head wall has been washed out.

4) Impact Basin (See Photo #6, 7, 8 & 9)

This structure shows signs of minor deterioration. The base of the downstream side of the baffle wall shows minor erosion from cavitation. The upstream face was submerged and could not be observed. The left end of the service platform has spalled over a 12 inch by 4 inch area. This spalling is attributed to excessive concrete vibration. A reinforcing rod located on the top surface is exposed. Immediately to the left of the outlet conduit there is honey combing 9 inches long and 1 inch high in the headwall. There is minor seepage through the honeycombed surface. The left sidewall is stained at the location of the toe drain outlet. There is no safety barrier around this structure.

(d) Reservoir Area

The shore of the reservoir is generally shallow sloping woodland. It appears stable and in good condition.

(e) Downstream Channel

The downstream channel is a narrow channel passing over relatively flat ground and leading directly into Water Loom Pond. The channel appears stable and in good condition.

3.2 Evaluation

The dam is generally in good condition. The impact basin is in fair condition. The potential problems noted during the visual inspection are listed below.

a) Animal burrows in downstream slope of embankment.

b) Saplings growing in downstream slope of embankment.

c) Debris in trash racks.

d) Seepage through headwall of impact basin.

e) Seepage from right toe drain.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures

No written operational procedures exist for this dam. The dam is self regulating.

4.2 Maintenance of Dam

An annual inspection is made jointly by the New Hampshire Water Resources Board and the Soil Conservation Service. Recommendations resulting from this inspection are implemented by the NHWRB.

4.3 Maintenance of Operating Facilities

Operation of the sluice gate for the pond drain inlet is checked approximately once every four or five years by NHWRB.

4.4 Description of Warning System in Effect

There is no warning system in effect.

4.5 Evaluation

The established operational procedures for this dam are generally satisfactory. Additional emphasis on routine maintenance will assist the owners in assuring the long-term safety of the dam.

SECTION 5 - HYDROLOGY/HYDRAULICS

5.1 Evaluation of Features

(a) General

Souhegan River Watershed Dam No. 35 is a Soil Conservation Service (SCS) flood control dam on the West Branch of the Souhegan River in New Ipswich, New Hampshire. The dam is about 300 feet upstream of Binney Hill Road, and about 2,300 feet upstream of the village of Smithville. The upstream drainage area is 6.3 square miles with rolling topography.

The dam itself is a 1,209 foot earthen embankment with a 255 foot wide grass-lined, emergency spillway. The principal spillway consists of three orifices located on a riser in the reservoir. Flow from the orifices proceeds under the dam through a 36 inch diameter, reinforced concrete pipe.

(b) Design Data

The elevation of the low stage inlet was determined by the 50 year sedimentation level of the watershed. The high stage inlet was set to allow storage of the four year, six hour storm without water passing over the high stage inlet. The emergency spillway crest was set to allow storage of the 100 year storm and the top of dam was determined based on the Probable Maximum Flood

The data sources available for Souhegan River Watershed Dam No. 35 include the Soil Conservation Service's (SCS) "Hydrology and Hydraulics" Design Calculations. These calculations include Storage-Elevation and Stage-Discharge curves for the dam, and the routing of storms of various magnitudes through the reservoir. These calculations are dated 1962 and 1963.

Also available are SCS "Maintenance Checklist" reports on dam inspections dated May 19, 1977 and June 16, 1978; and a July 19, 1978 SCS memorandum discussing damage to the control section of the emergency spillway.

The Soil Conservation Service As-Built plans, dated 1963, are also available for this dam.

(c) <u>Experience Data</u>

No records of flow or stage are known to be available for Souhegan River Watershed Dam No. 35.

(d) <u>Visual Observations</u>

Souhegan River Watershed Dam No. 35 is a flood control structure on the West Branch of the Souhegan River about 2,300 feet upstream of the village of Smithville, New Hampshire. The dam consists of a 1,209 foot long earthen embankment with a crest elevation of 1,090 feet MSL.

The emergency spillway is a 255 foot wide grass-lined channel, with its crest at 1,083 feet MSL, and with a 410 foot approach from the lake and 2:1 side slopes. The principal spillway consists of a concrete riser structure in the reservoir with three orifices. The flow from these orifices combines in the riser and flows under the dam through a 36 inch reinforced concrete pipe 160.6 feet long.

The channel immediately downstream of the dam is the tail end of a small pond created by a dam about 500 feet downstream of the Souhegan River Watershed Dam No. 35. This pond is crossed by Binney Hill Road between Souhegan River Watershed Dam No. 35 and the pond's dam.

The first development in the flood plain downstream of the dam is the village of Smithville, which is built around another pond on the West Branch of the Souhegan. This pond is created by a 15 foot high wood and rubble dam. Goen Road crosses the pond about 50 feet upstream of this dam. The pond crosses under Goen Road through a 13 foot by 7.7 foot arch corrugated metal culvert. There are two houses at about the level of the road upstream from Goen Road, and two more houses are located downstream of the road. One of these houses is at road level. The other is four feet above road level.

Downstream of Smithville, the West Branch enters a steep, narrow gorge for a few hundred feet, and then runs about 1.5 miles to Ashby Road. The only development in this stretch is a lumber yard on the north bank. The bridge at Ashby Road is a concrete structure with a 12.5 foot by 28 foot rectangular opening. Just downstream of this road is a house with a garage apartment 12 to 14 feet above the streambed.

The West Branch then runs about 1/2 mile to River Road, and another 1/8 mile to join the Souhegan River just upstream of Water Loom Pond.

(e) Test Flood Analysis

The hydrologic conditions of interest in this Phase I investigation are those required to assess the dam's overtopping potential and its ability to safely allow an appropriately large flood to pass. This requires using the discharge and storage characteristics of the structure to evaluate the impact of an appropriately sized Test Flood. The original hydraulic and hydrologic design calculations of the SCS are available for this dam.

Guidelines for establishing a recommended Test Flood based on the size and hazard classification of a dam are specified in the "Recommended Guidelines" of the Corps of Engineers. The maximum impoundment of 1,787 acre feet and the height of 30 feet classify this dam as an INTERMEDIATE structure.

The appropriate hazard classification for this dam is HIGH because of the significant economic losses and potential for loss of life in the event of dam failure. As shown in the following section, the increase in flooding caused by failure would pose a threat to property and to lives in the village of Smithville, where three houses would be seriously flooded, and others would also receive damage. Other impacts of dam failure include possible damage to several well-travelled roads, damage to a lumber yard, and damage to Water Loom Pond Dam on the Souhegan and structures downstream of that dam (see Dam Failure Analysis section).

As shown in Table 3 of the Corps of Engineers' "Recommended Guidelines," the appropriate Test Flood for a dam classified as INTERMEDIATE in size with a HIGH hazard potential would be the probable maximum flood (PMF). As part of their hydraulic and hydrologic design calculations for the dam, the SCS created a "Freeboard Hydrograph" (equivalent to the PMF) and routed it through the reservoir using a storage router. The peak inflow is 17,160 cfs, which is 2,724 csm on a 6.3 square mile drainage area. This compares to the 1,780 csm given on the Corps of Engineers' "Maximum Probable Peak Flow Rates" curve assuming rolling topography, and 2100 csm assuming mountainous topography.

The SCS storage routing, which begins with the reservoir level at 1,068 feet MSL (1.0 feet above normal pool) gives a peak outflow of 12,670 cfs with the water surface at 1,089.9 feet MSL, 0.1 foot below the top of the dam. The reservoir's drawdown time from the emergency spillway crest (1,083.0 feet MSL) to 1,068 feet MSL is 6.2 days.

(f) Dam Failure Analysis

The peak outflow that would result from the failure of Souhegan River Watershed Dam No. 35 is estimated using the procedure suggested in the Corps of Engineers New England Division's April 1978 "Rule of Thumb Guidelines for Estimating Downstream Dam Failure Hydrographs," as clarified in a December 7, 1978 meeting at the Corps' Waltham office. Normally this procedure is carried out with dam failure assumed to occur when the water surface reaches the top of the dam. In this case, however, the outflow of 13,061 cfs with the water surface at the top of the dam (1,090 feet MSL) is greater than the Probable Maximum Flood (PMF) routed outflow at the dam. Also, this outflow would create serious flooding downstream prior to dam failure. Therefore, failure is assumed to occur with the water surface at the SCS Design High water of 1,085.4 feet MSL, 4.6 feet below the top of the dam.

The discharge just prior to failure at this elevation is given by the Stage-Discharge curve developed in Appendix D as 2,625 cfs. The tailwater elevation prior to failure at this discharge would be about 1,067.3 feet MSL (7 feet of flow in the channel).

For an assumed breach width equal to 40% of the dam width at the half-height, the gap in the embankment due to failure would be 180 feet. The resulting increase in flow would be 23,300 cfs, or a total flow of about 26,000 cfs. This would increase the tailwater elevation by 6 feet. The only location of interest immediately downstream of the dam is the bridge across Binney Hill Road, which would probably be damaged by the dam failure outflow.

The next damage center downstream on the West Branch of the Souhegan would be the village of Smithville, about 2,300 feet from the dam. The channel leading to the village is a series of linked ponds whose storage would attenuate the peak outflow somewhat. Smithville consists of 10 to 15 houses located on a pond created by a small dam on the West Branch. Fifty feet upstream of this dam, Goen Road crosses the pond. There are four houses which would be seriously affected by dam failure flooding. Two are upstream of the road at road level (12 feet above the streambed) and two are downstream of the road, one at road level and one four feet above road level.

At high flows, the controlling cross-section at Smithville is Goen Road, which is on an embankment with a 13 foot by 7.7 foot corrugated metal arch culvert. It is quite possible that the embankment would wash out under dam failure flows, but this area would still serve as a constriction, since the West Branch of the Souhegan enters a narrow rock gorge just downstream of the town.

The pre-failure flow of 2625 cfs would create a water surface 2 feet above the roadway, 14 feet above the streambed. This would cause significant flooding in the three lowest houses around the pond. After dam failure, the attenuated peak flow at Smithville would be 22,800 cfs, which would result in a water surface 8 feet above Goen Road (20 feet above the streambed) an increase of 6 feet. This would certainly cause serious damage to the three low-lying houses, and would create flooding at the house four feet above the streambed. In addition, 3 to 5 other houses in Smithville could receive minor flooding. If the Goen Road embankment were to fail, the flood levels at Smithville might be lowered somewhat, although they would still be dangerously high. The sudden increase in flooding at Smithville caused by dam failure presents a threat of loss of life.

The West Branch of the Souhegan passes through the rocky gorge downstream of Smithville and enters a relatively broad flood plain. The next damage center is a lumber yard located about twelve feet above the streambed 3,800 feet downstream of Smithville. The pre-failure outflow of 2,625 cfs would result in 8 feet of flow in the channel in this area. After dam failure the attenuated peak flow at the lumber yard would be 19,500 cfs, which would cause the depth of flow to increase 5 feet to 13 feet. This flow would probably cause some flooding at the lumber yard, and might damage stored lumber.

The West Branch of the Souhegan then runs 2800 feet through a broad flood plain to a bridge under Ashby Road. The attenuated flow at Ashby Road would be 17,500 cfs, and the depth of flow would increase from 7 feet to 10 feet. This flow might damage the bridge at Ashby Road. Just downstream of Ashby Road, there is a house with an attached garage apartment. The apartment is about twelve feet above the streambed and the house about fourteen feet. These would probably escape serious flooding after dam failure.

From Ashby Road the stream proceeds about 3400 feet to the junction with the Souhegan River. In this reach the West Branch passes under River Road, which would probably be damaged by dam failure outflow. The attenuated peak failure flow at the juncture with the Souhegan River would be 15,000 cfs, and the flow depth would increase from 7 to 9 feet above the streambed. There are no dwellings in this reach.

The Souhegan is a wide, meandering stream with a broad, marshy flood plain in this area. Within 2500 feet of its juncture with the West Branch, the Souhegan enters Water Loom Pond. The inflow to Water Loom Pond caused by the failure of Souhegan River Watershed Dam No. 35 would raise the stage in Water Loom Pond considerably. Whether this increase would cause overtopping and/or failure of Water Loom Pond Dam is dependent on antecedent water levels in the pond and other factors. The separate report on Water Loom Pond Dam discusses the possible downstream impacts of failure of this dam.

The following table summarizes the effects of the failure of Souhegan River Watershed Dam No. 35.

IMPACT OF DAM FAILURE

Location Number (see map, page D-17)	Flow Depth Before Failure (ft.)	Flow Depth After Failure (ft.)	Peak Flow After Attenuation (cfs)	Comments
At Dam	-	-	26,000	
1. Tail-water, and at Binney Hill Rd.	7	13	26,000	Could damage or destroy Binney Hill Rd. Bridge
2. Smith-ville at Road	14	20	22,800	Increases flooding at two houses from 2 ft. to 8 ft. At 3rd house from 2 ft ± to less than 8 ft. ±. Dan-ger of loss of life. Some flooding to 3 to 5 other homes possible.
3. Lum-ber Yard	8	13	19,500	Minor flooding (1 to 2 ft. ±)
4. Ashby Rd. Bridge	7	10	17,500	Damage to bridge, and possibly to house just downstream
5. Sou-hegan Con-fluence	7	9	15,000	Damage to River Rd. Bridge. Possible damage to Water Loom Pond Dam on the Sou-hegan and downstream struc-tures.

*The flow depth at Smithville is greater than at other locations because of the constrictions caused by Goen Rd. and by the stream's narrowing at this point. These constrictions would create the large depths shown.

SECTION 6 - STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

(a) Visual Observations

There has been no significant displacement or distress which would warrant the preparation of structural stability calculations.

(b) Design and Construction Data

1) Embankment

Analysis carried out during the design and construction phase included an embankment slope stability analysis by the swedish circle method. A number of trial failure arcs were made for the 3:1 upstream slope with drawdown to the base assumed. A factor of safety of 1.26 was calculated with a 10 foot berm. A 3:1 downstream slope trial gave a factor of safety of 1.89. Based on these analyses, a 3.5 to 1 upstream slope with berm, and a 3 to 1 downstream slope were utilized.

2) Appurtenant Structures

A review of structural calculations for the design of the drop inlet service spillway structure and the outlet conduit (primary spillway) revealed that these structures have been designed on the basis of sound engineering practice.

(c) Operating Records

There are no known operating records for this dam.

(d) Post Construction Changes

There have been no known construction changes since the dam was completed in 1965.

(e) Seismic Stability

The dam is located in seismic zone No. 2 and, in accordance with the recommended Phase I guidelines, does not warrant seismic analysis.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

(a) Condition

The dam and its appurtenances are generally in good condition at the present time with the exception of the impact basin which is in fair condition.

(b) Adequacy of Information

There is sufficient design and construction data to permit an assessment of dam safety when combined with the visual inspection, past performance, and sound engineering judgment.

(c) Urgency

The recommendations and remedial measures described herein should be implemented by the owner within two years of receipt of this phase I Inspection Report.

(d) Need for Additional Investigations

None

7.2 Recommendations

No conditions were observed which warrant the attention of a registered engineer

7.3 Remedial Measures

It is recommended that the owner institute the following remedial measures.

1) Check the operability of the pond drain inlet gate as part of the annual inspection procedure.

2) Monitor seepage through the impact basin headwall.

3) Monitor seepage from right toe drain, especially under high reservoir conditions.

4) Remove saplings in downstream slope [illegible] roots, from slopes, Resulting voids [illegible] filled with suitable compacted materia[illegible]

5) Implement and intensify a program [illegible] periodic maintenance including [illegible] Backfilling animal burrows in slope [illegible] with suitable, well-tamped soil [illegible] embankment; and clearing debris [illegible]

6) Develop a downstream emergency flood [illegible]

7) Maintain the program of annual tech[illegible]

7.4 Alternatives

There are no meaningful alternatives to the [illegible] mendations.

APPENDIX A

VISUAL INSPECTION CHECKLIST

INSPECTION TEAM ORGANIZATION

Date: May 14, 1979

Project: NH 00435
SOUHEGAN RIVER WATERSHED PROJECT FLOODWATER
RETARDING DAM NO. 35
New Ipswich, New Hampshire
NHWRB 175.21

Weather: Overcast, drizzle, cool

INSPECTION TEAM

Nicholas A. Campagna	Goldberg, Zoino, Dunnicliff & Assoc. (GZD)	Team Captain
William S. Zoino	GZD	Soils
M. Daniel Gordon	GZD	Soils
Jeffrey M. Hardin	GZD	Soils
Paul Razgha	Andrew Christo Engineers, Inc., (ACE)	Structures
Carl Razgha	ACE	Structures
Tom Gooch	Resource Analysis, Inc. (RAI)	Hydrology
Robert Fitzgerald	RAI	Hydrology

Owner's Representative Present:

Gary Kerr - New Hampshire Water Resources Board

SOUHEGAN RIVER WATERSHED RETARDING
DAM NO. 35
New Ipswich, New Hampshire

May 14, 1979
NH 00435

CHECK LISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION & REMARKS
DAM EMBANKMENT		
Crest elevation	NAC	1090.0 ft. MSL
Current pool elevation		1067.0 ft. MSL
Maximum impoundment to date		Unknown
Surface Cracks		None
Pavement condition		Not applicable
Movement or settlement of crest		None
Lateral Movement		None
Vertical alignment		Good
Horizontal alignment		Good
Condition at abutments and at concrete structures		Good
Indications of movement of structural items on slopes		None
Trespassing on slopes		Few small rodent holes downstream slope; 1 small sapling right downstream slope; tire ruts 6-8" deep right upstream slope
Sloughing or erosion of slopes or abutments		4-6" erosion due to wave action on upstream slope to right of outlet structure
Rock slope protection - riprap failures		No riprap-upstream slope good except as noted above
Unusual movement or cracking at or near toes		None
Unusual embankment or downstream seepage	NAC	Left toe drain 2 gpm Right toe drain 50 gpm

SOUHEGAN RIVER WATERSHED RETARDING
DAM NO. 35
New Ipswich, New Hampshire

May 14, 1979
NH 00435

CHECK LISTS FOR VISUAL INSPECTION

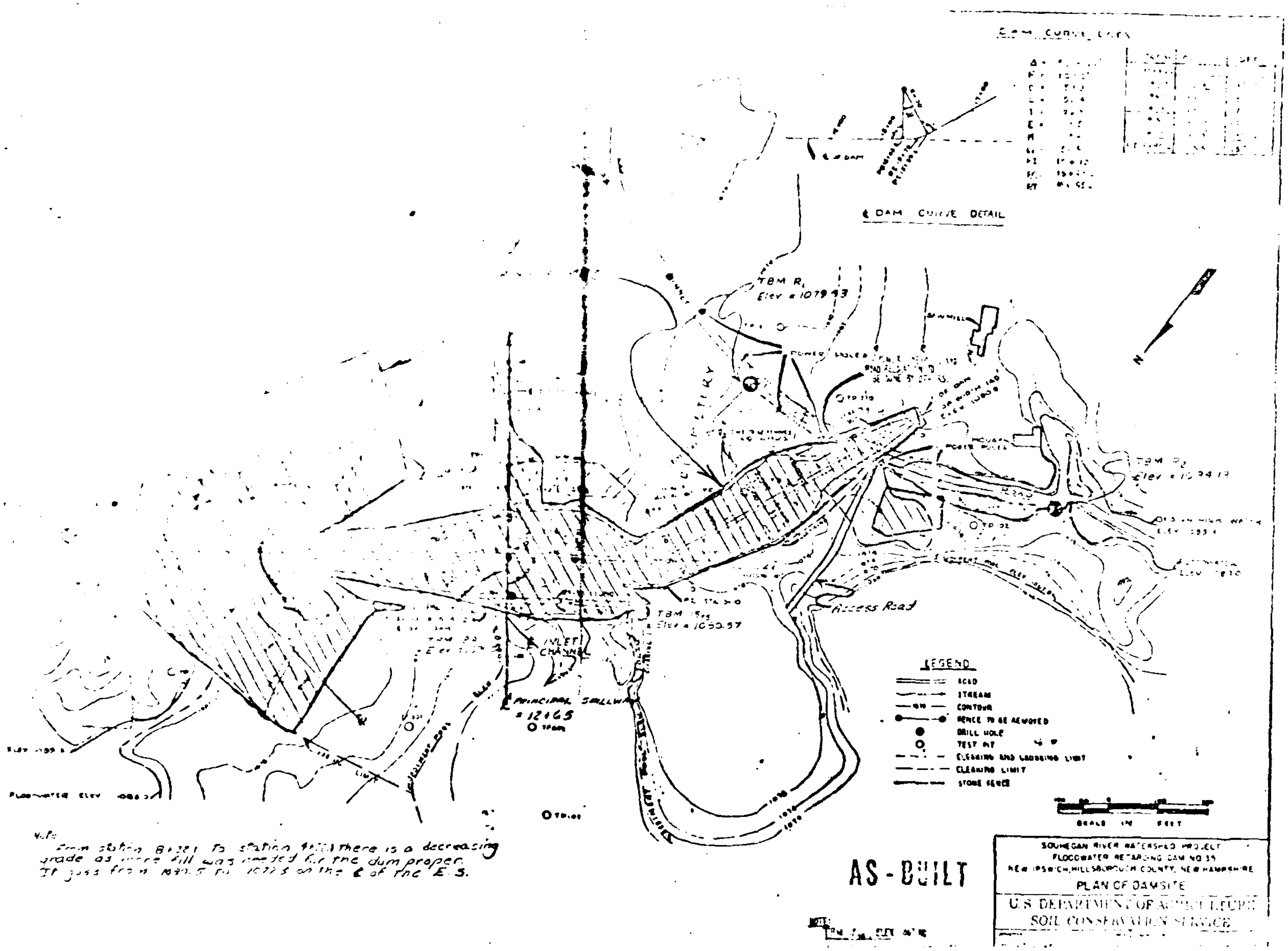
AREA EVALUATED	BY	CONDITION & REMARKS
DAM EMBANKMENT - cont.	NAL	
Piping or boils		None
Foundation drainage features		Toe drains functioning as above
Toe drains		Functioning as above
Instrumentation system	NAL	None
APPURTENANT STRUCTURES		
A. Drop Inlet Service Spillway Structure		
Condition of concrete		Good
Spalling		None noted
Erosion		None noted
Cracking		None noted
Rusting or staining of concrete		None noted
Visible reinforcing		None noted
Efflorescence		None noted
Trash Racks		
Upper stage trash racks		No deficiencies noted
Lower stage trash rack		Trash rack in good condition but clogged with debris
Gate bench stand		No deficiencies noted
B. Reservoir Discharge Conduit		Submerged, could not be observed
C. Outlet Conduit (primary spillway)	PR	No deficiencies noted with exception of missing pre-formed joint filler

SOUHEGAN RIVER WATERSHED RETARDING
DAM NO. 35
New Ipswich, New Hampshire

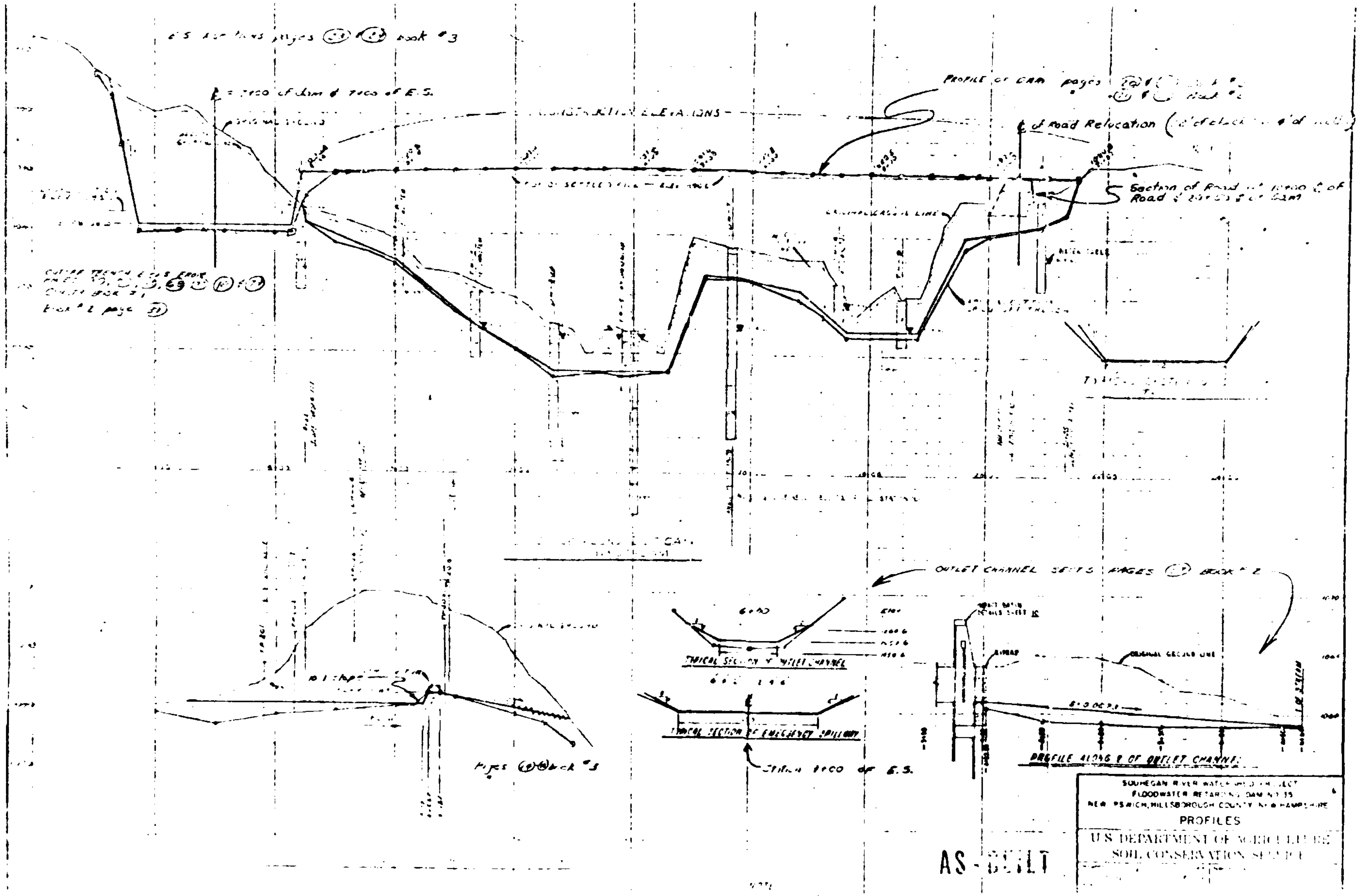
May 14, 1979
NH 00435

CHECK LISTS FOR VISUAL INSPECTION

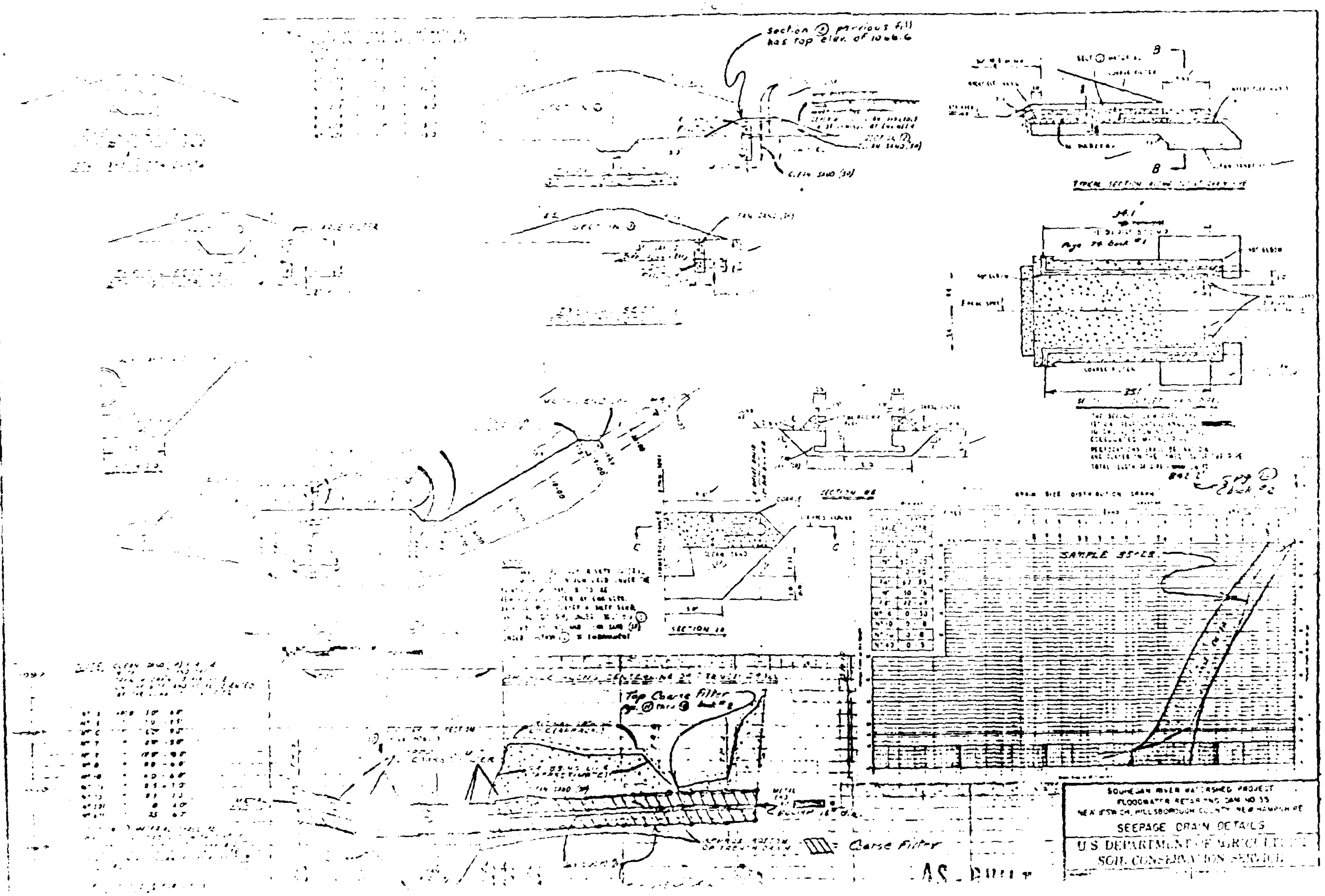
AREA EVALUATED	BY	CONDITION & REMARKS
D. Impact Basin		
Condition of concrete	PR	Fair
Spalling		Top surface of service platform 12" x 4"
Erosion		Minor at base of baffle wall
Cracking		None noted
Rusting or staining of concrete		Heavily stained at location of left toe drain outlet
Visible reinforcing		One reinforced rod on top of service platform exposed for 12"
Efflorescence		None noted
Honeycombs	PR	12" x 1" on headwall, seepage flowing through surface.

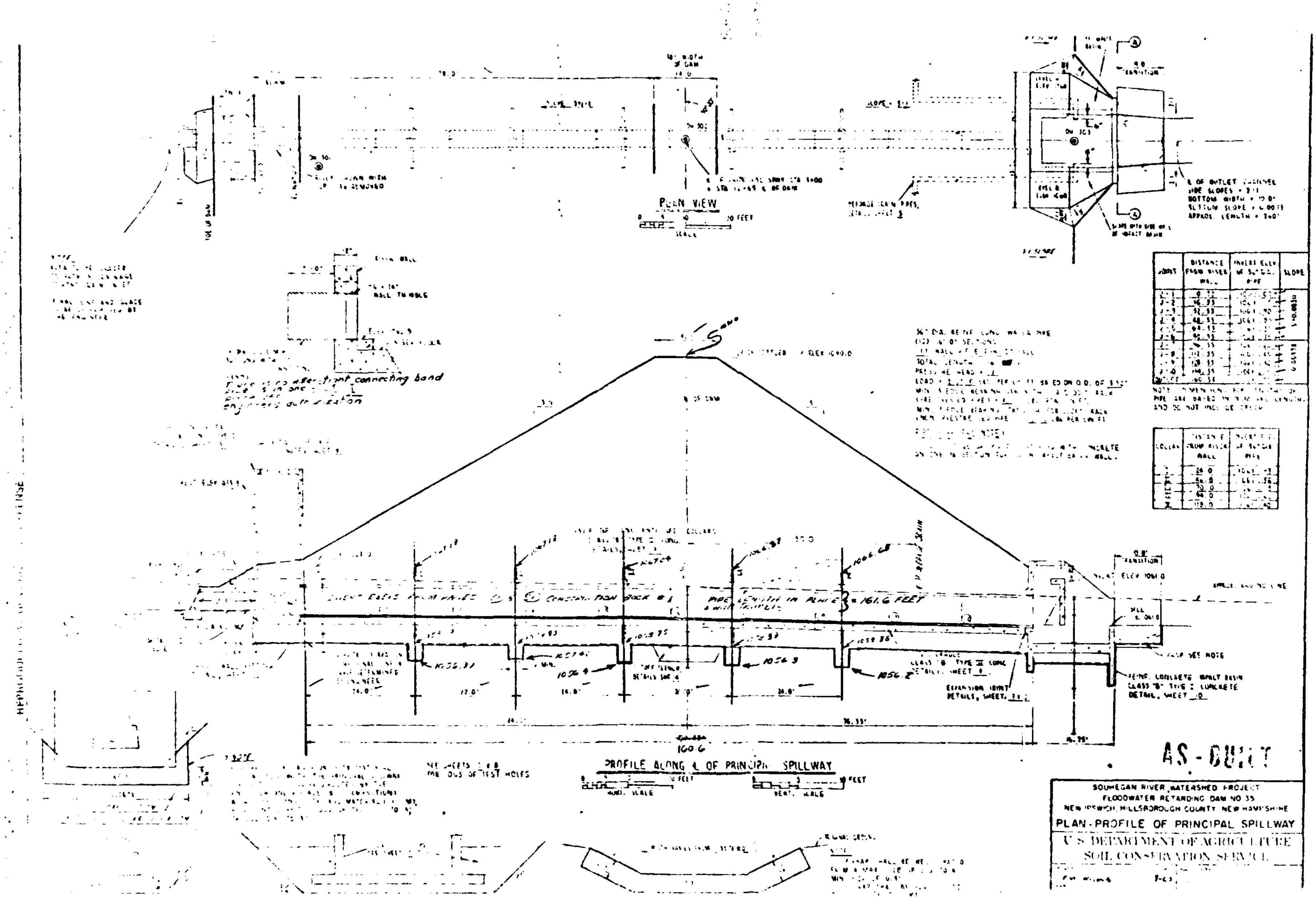


Note:
From station 8+321 to station 9+00 there is a decreasing grade as more fill was needed for the dam proper. It goes from 1081.5 to 1077.5 on the ℄ of the E.S.



Profile of dam pages
of Road Relocation
Section of Road
Original ground line
Typical section of outlet channel
Typical section of emergency spillway
Outlet channel sects pages
Profile along ℄ of outlet channel
Riprap
SOUHEGAN RIVER WATERSHED PROJECT
FLOODWATER RETARDING DAM NO 35
NEW IPSWICH, HILLSBOROUGH COUNTY, NEW HAMPSHIRE
PROFILES
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
AS-BUILT


Section ② previous fill has top elev. of 1066.6
Top Coarse Filter
Carse Filter
SAMPLE 35-CE
AS BUILT
SOUHEGAN RIVER WATERSHED PROJECT
FLOODWATER RETARDING DAM NO 35
NEW IPSWICH, HILLSBOROUGH COUNTY, NEW HAMPSHIRE
SEEPAGE DRAIN DETAILS
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE


PLAN VIEW
PROFILE ALONG ℄ OF PRINCIPAL SPILLWAY
Pipe length in place = 161.6 FEET
160.6
AS-BUILT
SOUHEGAN RIVER WATERSHED PROJECT
FLOODWATER RETARDING DAM NO 35
NEW IPSWICH, HILLSBOROUGH COUNTY, NEW HAMPSHIRE
PLAN-PROFILE OF PRINCIPAL SPILLWAY
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

0 [illegible] Topsoil
[illegible] GRAVEL, poorly graded, [illegible] GP
[illegible]
[illegible] SAND, [illegible] moist, olive-brown color, SM
[illegible] boulders, [illegible] (over 12"), [illegible]
[illegible]
The [illegible] feet of hole consists of [illegible] angular [illegible] boulders.

TP-[illegible], ELEV. [illegible]

0 0.5 Topsoil
[illegible] SAND, fine, uniform, poorly graded, [illegible] brown color, [illegible] SM
[illegible] GRAVEL, poorly graded, rounded, moist, [illegible] GP
[illegible] SAND, medium, [illegible] gravel, poorly graded, [illegible] pervious [illegible] SP
[illegible] GRAVEL, [illegible] rounded, wet, [illegible] partially cemented, pervious, compact, glacial outwash. GP
[illegible] SAND, silty, wet, olive gray color, semi pervious to impervious, dense, non-plastic, [illegible] subangular cobbles [illegible] glacial till. SM
[illegible] BEDROCK, [illegible] moist, solid, [illegible]
Water table at [illegible]

TP-[illegible], ELEV. [illegible]

[illegible] PEAT, black OL
[illegible] SILT, sandy, wet, olive-brown color, pervious, soft, [illegible] massive, pocket [illegible] ML
[illegible]
[illegible] GRAVEL, [illegible] graded, rounded, with [illegible] sand, [illegible] pervious, loose, [illegible] GP
[illegible] SILT, wet, [illegible] gray color, [illegible] ML
[illegible]
[illegible]
Fresh surfaced boulder of [illegible] exposed at bottom of test pit.
Hole caved in and filled to [illegible]
Water table at [illegible]

TP-[illegible], ELEV. [illegible]

0 [illegible] PEAT, black PT
[illegible] SAND, medium, uniform, poorly graded, [illegible] pervious, [illegible] SP
[illegible]
[illegible] PEAT, [illegible] PT
[illegible] GRAVEL, poorly graded, rounded with [illegible] sand, [illegible] pervious, loose, [illegible] GP
[illegible] SILT, [illegible] sand, wet, impervious and semi pervious, hard and soft, plastic, massive, [illegible] ML
Hole caved in and filled to [illegible]
Water table at [illegible]
[illegible] sample [illegible] Shelby? container at [illegible]

TP-[illegible], ELEV. [illegible]

0 0.5 Topsoil
0.5 [illegible] SAND, coarse, well graded subrounded, dry, [illegible] color, clean, pervious, medium density, kame terrace. SW
[illegible] 9.0 SAND, medium, well graded, dry, yellow color, clean, pervious, medium density, kame terrace. SW
9.0 15.0 SAND, fine to medium, poorly graded, dry, light yellow color, clean, pervious, medium density, kame terrace. SP
15.0 16.0 SAND, very fine, uniform, poorly graded, wet, light yellow color, with silt, pervious, medium density, [illegible], kame terrace. SM
Hole caved in and filled to 9.0'.
Water table at 15.5' 8-16-62

TP-[illegible], ELEV. [illegible]

0 [illegible] SAND, coarse, poorly graded, dry, yellow color, clean, pervious, medium density, kame terrace. SP
[illegible] SAND, coarse, poorly graded, saturated, light yellow color, clean, pervious, loose, [illegible] subrounded cobbles, kame terrace. SP
Water table at [illegible] 8-16-62

0 5.5 SAND, fine, poorly graded, dry, light yellow color, clean, pervious, medium density, iron-stained, fine stratification dipping 10° [illegible], kame terrace. SP
5.5 9.0 SAND, very fine, uniform, poorly graded, saturated, light yellow color, clean, pervious loose, [illegible], kame terrace. SM
Water boiled up from the bottom of the test pit.
Hole caved in and filled to 5.0'.
Water table at 5.5' 8-16-62

TP-[illegible], ELEV. [illegible]

0 0.5 Topsoil
0.5 7.0 GRAVEL, well graded, moist, yellow-brown color, clean, pervious, medium dense, glacial outwash. GW
7.0 15.0 SAND, silty, wet, olive-brown color, impervious, medium dense, slightly plastic, massive, 1% rounded cobbles (3-6"), 2% sub-rounded boulders (over 12"), glacial outwash. SM
Water table at 6.0' 8-17-62

TP-130, ELEV. [illegible]

0 0.5 Topsoil
0.5 [illegible] SAND, fine to medium, poorly graded, dry, light yellow color, clean, pervious, medium density, kame terrace. SP

TP-201, ELEV. [illegible]

0 0.5 Topsoil
0.5 6.0 SAND, silty, slightly moist, olive-brown color, semi-pervious, dense, slightly plastic, massive, glacial till. SM
6.0 [illegible] SAND, silty, moist, olive gray color, impervious, very dense, plastic, tending to platyness, glacial till.
Water dripping from sides of test pit below [illegible].

TP-202, ELEV. [illegible]

0 0.5 Topsoil
0.5 [illegible] SAND, silty, slightly moist, olive brown color, semi pervious to impervious, dense, slightly plastic, massive, [illegible] subangular cobbles (3-6"), glacial till. SM

TP-[illegible], ELEV. [illegible]

0 0.5 Topsoil
0.5 9.0 SAND, silty, slightly moist, olive-brown color, semi pervious to impervious, dense, slightly plastic, massive, 1% subangular cobbles (3-6"), glacial till. SM
9.0 [illegible] SAND, silty, moist, olive gray color, impervious, very dense, plastic, tending to platyness, 1% subangular cobbles (3-6"), glacial till. SM
Water [illegible]
The lower [illegible] consists of [illegible], sub-angular boulders.

TP-[illegible], ELEV. [illegible]

0 0.5 Topsoil
0.5 9.0 SAND, silty, slightly moist, olive-brown color, semi pervious to impervious, dense, slightly plastic, massive, glacial till. SM
9.0 16.0 SAND, silty, moist, olive-gray color, impervious, very dense, plastic, tending to platyness, 1% subangular cobbles (3-6"), 1% angular boulders (over 12"), glacial till.
The lower [illegible] consists of [illegible], angular boulders.

TP-[illegible], ELEV. [illegible]

0 0.5 Topsoil
0.5 5.0 SAND, silty, slightly moist, olive-brown color, semi pervious, dense, slightly plastic, massive, 1% subangular cobbles (3-6"), glacial till SM

TP-[illegible], ELEV. [illegible]

0 0.5 Topsoil
0.5 9.0 SAND, silty, slightly moist, olive-brown color, semi-pervious to impervious, dense, slightly plastic, massive, glacial till. SM
9.0 16.0 SAND, silty, moist, olive-gray color, impervious, very dense, plastic, tending to platyness, 1% gravel size, 1% subangular cobbles (3-6"), 3% angular boulders (over 12"), glacial till. SM

0 0.5 Topsoil
0.5 [illegible] SAND, silty, slightly moist, olive-brown color, semi pervious to impervious, dense, slightly plastic, massive, 3% gravel size, glacial till. SM
8.0 15.0 SAND, silty, moist, olive-gray color, impervious, very dense, plastic, tending to platyness, 3% gravel size, 1% sub-angular cobbles [illegible], glacial till. SM

TP-209, ELEV. [illegible]

0 1.0 Topsoil
1.0 6.0 SAND, silty, dry, light olive-brown color, pervious to semi pervious, medium dense, slightly plastic, massive, glacial till SM
6.0 15.0 SAND, silty, slightly moist, dark olive-brown color, semi pervious, dense, slightly plastic, massive, 3% subangular cobbles (3"-6"), glacial till. SM

TP-210, ELEV. [illegible]

0 0.5 Topsoil
0.5 5.0 GRAVEL, coarse, well graded subrounded, dry, iron-stain, yellow-brown color, clean, pervious, medium dense, kame terrace. GW
5.0 7.0 SAND, medium, well-graded, dry, yellow color, clean, pervious, medium density, kame terrace. SW
7.0 12.0 SAND, fine to medium, poorly graded, dry, light yellow color, clean, pervious, medium density, kame terrace. SP

TP-211, ELEV. [illegible]

0 1.0 Topsoil
1.0 [illegible] SAND, very fine, uniform, silty, dry, [illegible] color, pervious, medium density, kame terrace. SM
[illegible] SAND, very fine, uniform, silty, dry, yellow-brown, pervious, medium density, kame terrace. SM
[illegible] 15.0 SAND, fine to medium, poorly graded, slightly moist, light yellow color, clean, pervious, medium density, mixed stratification dipping toward [illegible], kame terrace. SP

TP-[illegible], ELEV. [illegible]

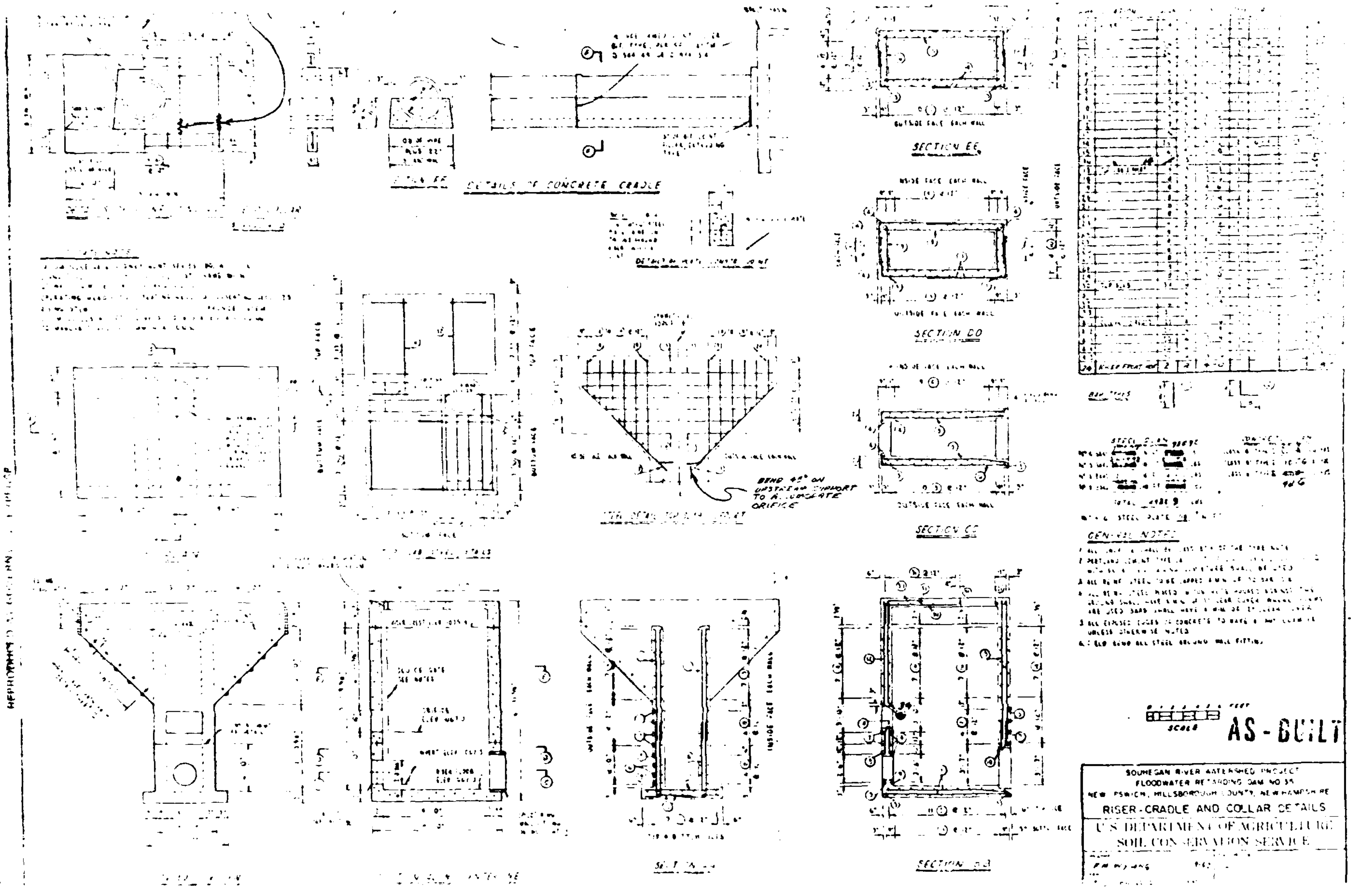
0 0.5 Topsoil
0.5 [illegible] GRAVEL, poorly graded, rounded with medium sand, moist, reddish-brown color with iron stain, medium dense, pervious, glacial outwash. GP
[illegible] GRAVEL, poorly graded, rounded, with medium sand, wet, black staining, partially cemented, pervious, compact, glacial outwash. GP
[illegible] 15.0 SAND, silty, wet, olive-brown color, semi-pervious, medium dense, possibly slightly plastic, massive, [illegible] rounded [illegible] (3-6"), [illegible] boulders (over 12") glacial outwash. SM
[illegible] SAND, silty, wet, gray color, impervious, [illegible] dense, plastic, massive, [illegible] angular [illegible], glacial till. SM
Hole caved in and filled to [illegible]
Water table at [illegible] 8-17-62

TP-[illegible], ELEV. [illegible]

0 0.5 Topsoil
0.5 [illegible] GRAVEL, poorly graded, rounded with medium sand, moist, reddish-brown color with iron stain, medium dense, pervious, glacial outwash. GP
9.0 [illegible] GRAVEL, poorly graded, rounded, wet, black staining, partially cemented, pervious, compact, glacial outwash. GP
16.0 15.0 SAND, very silty, wet, olive-brown color, impervious, dense, slightly plastic, massive, glacial outwash. SM
Water table at 9.5' 8-17-62

AS-BUILT

SOUHEGAN RIVER WATERSHED PROJECT
FLOODWATER RETARDING DAM NO 35
NEW IPSWICH, HILLSBOROUGH COUNTY, NEW HAMPSHIRE
LOGS OF TEST HOLES
U S DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE



SECTION EE
SECTION DD
SECTION CC
SECTION BB
DETAILS OF CONCRETE CRADLE
BEND 45° ON UPSTREAM SUPPORT TO ACCOMODATE ORIFICE
GENERAL NOTES
SCALE
FEET
AS-BUILT
SOUHEGAN RIVER WATERSHED PROJECT
FLOODWATER RETARDING DAM NO 35
NEW IPSWICH, HILLSBOROUGH COUNTY, NEW HAMPSHIRE
RISER-CRADLE AND COLLAR DETAILS
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

The U.S.D.A. Soil Conservation Service (SCS) located in Durham, New Hampshire, maintains a file for this dam. Included in this file are:

1) SCS "Design Report" dated 12/12/62.

2) SCS "Hydrology and Hydraulics" design calculations dated 1962.

3) SCS structural design calculations dated 1962.

4) SCS "Detailed Geological Investigation of Dam Sites" dated 1962.

5) SCS soil mechanics laboratory data sheets dated January 1963.

6) SCS "As Built" drawings dated 1964.

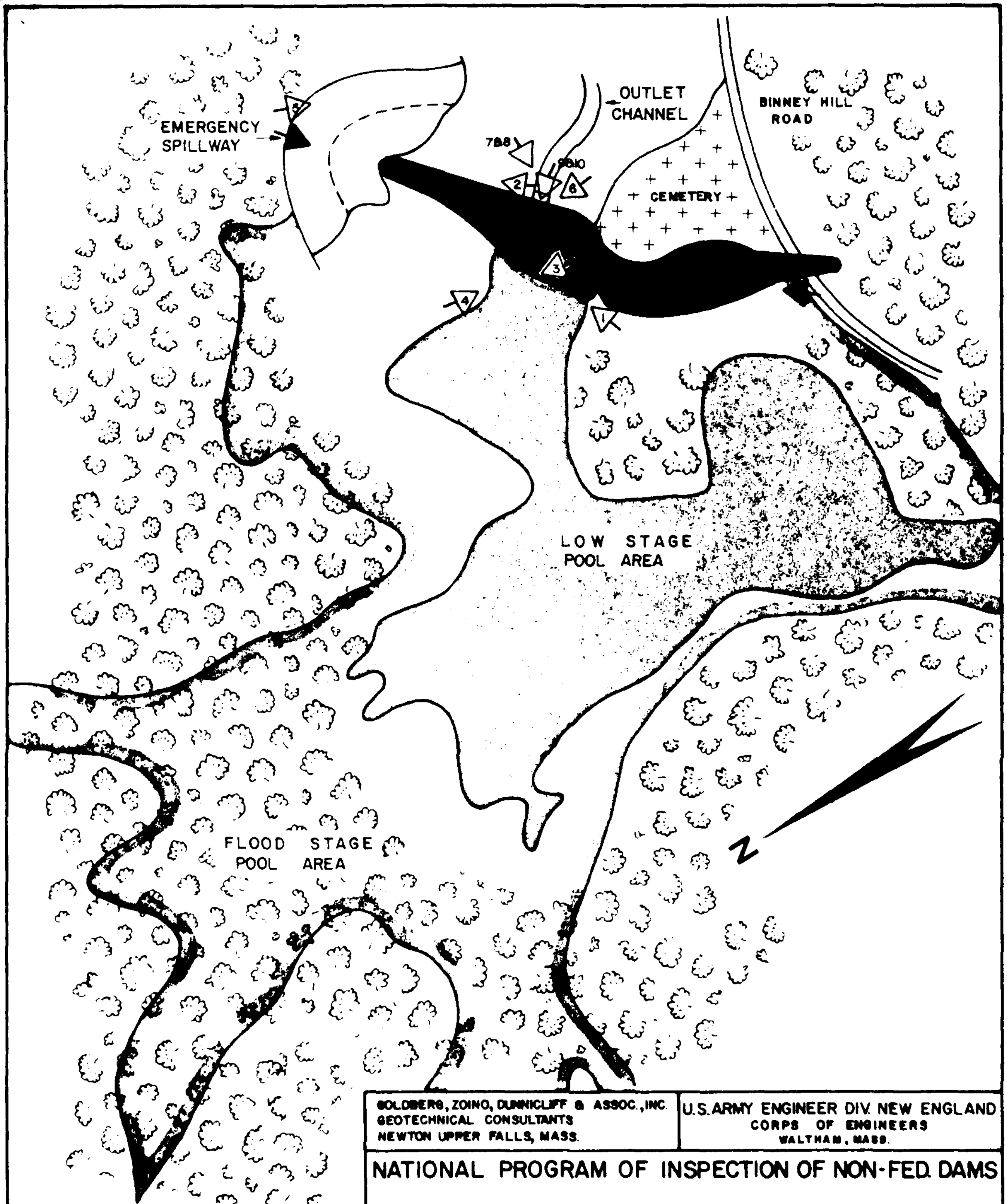
The New Hampshire Water Resources Board (NHWRB) maintains a correspondence file on this dam. Included in this file are:

1) Maintenance inspection checklists dated May 19, 1977 and June 16, 1978.

2) Memo discussing alleged damage to emergency spillway control section dated July 19, 1978.

APPENDIX C

PHOTOGRAPHS



OVERVIEW

APPENDIX C

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCATION AND ORIENTATION OF PHOTOS

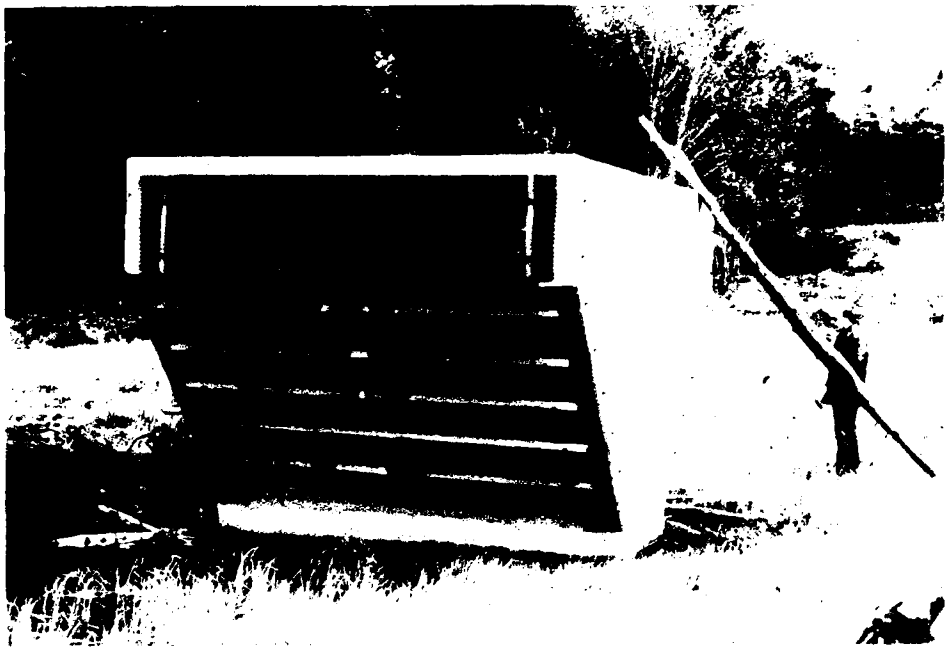
SOUHEGAN RIVER WATERSHED
DAM No. 35 NEW HAMPSHIRE

FILE No. 2327

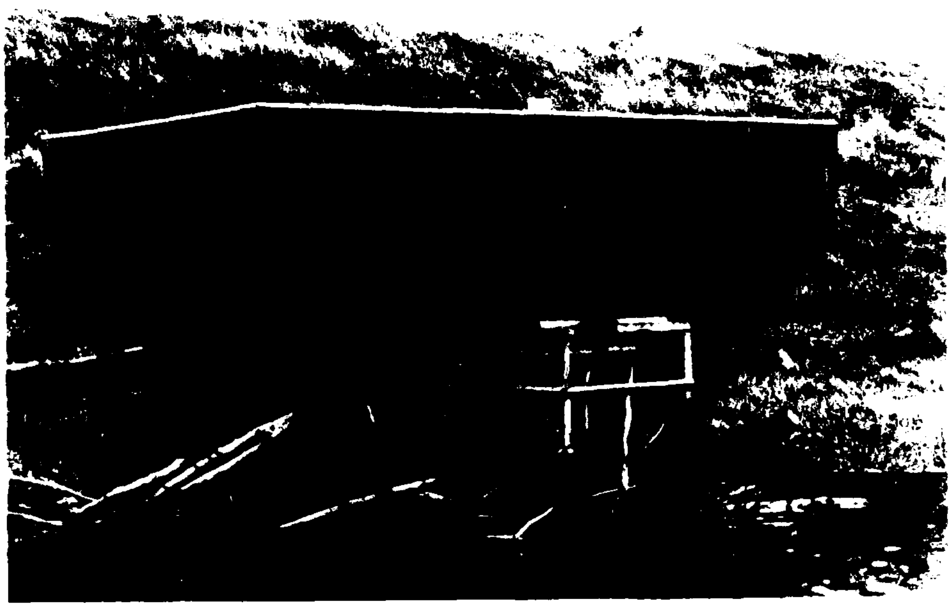
SCALE 1" = 200'
DATE MAY 1979

1. View of upstream slope from right side

2. View of downstream slope showing heavy grass and brush growth

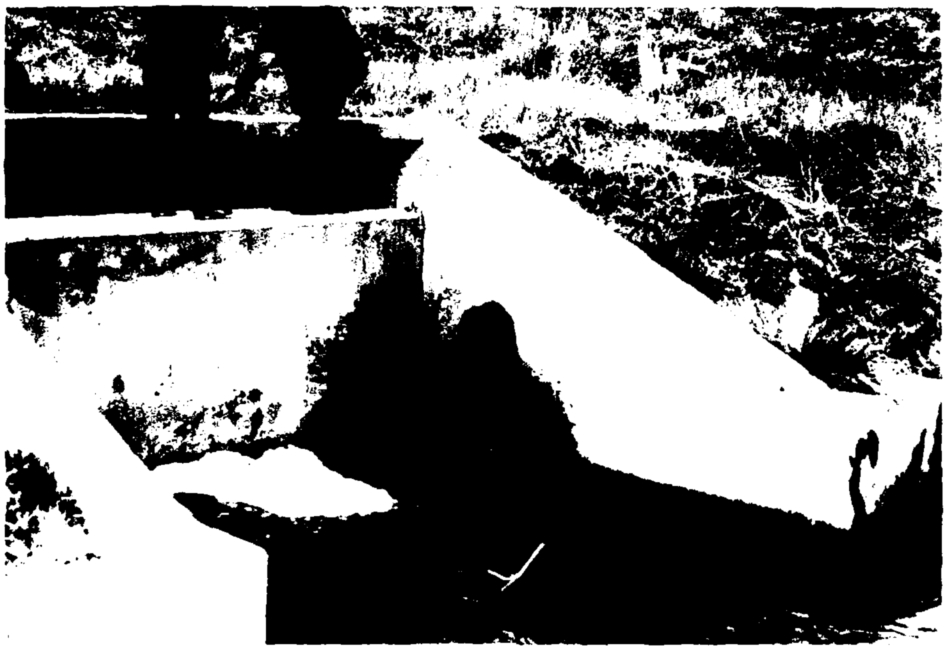


3. View of right side of inlet structure showing high stage inlet and trash rack



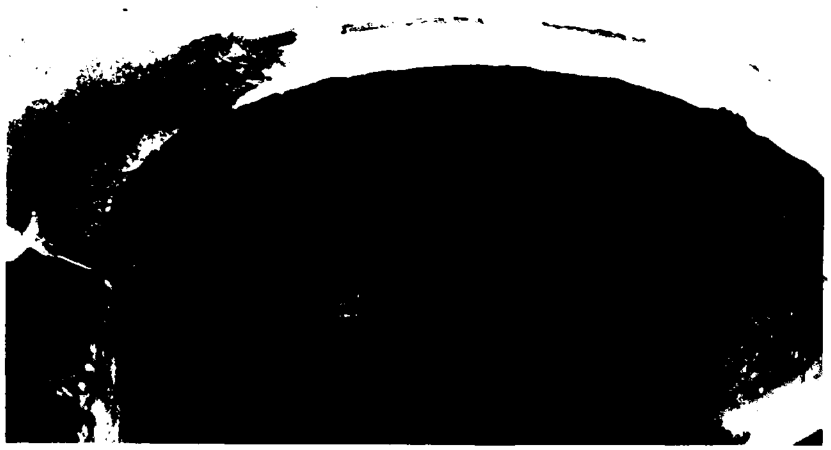
4. View of upstream and left sides of inlet structure showing debris in low stage trash rack

5. View of emergency spillway looking downstream



6. View of impact basin showing baffle and left toe drain outlet

9. Detail photo of seepage through concrete headwall

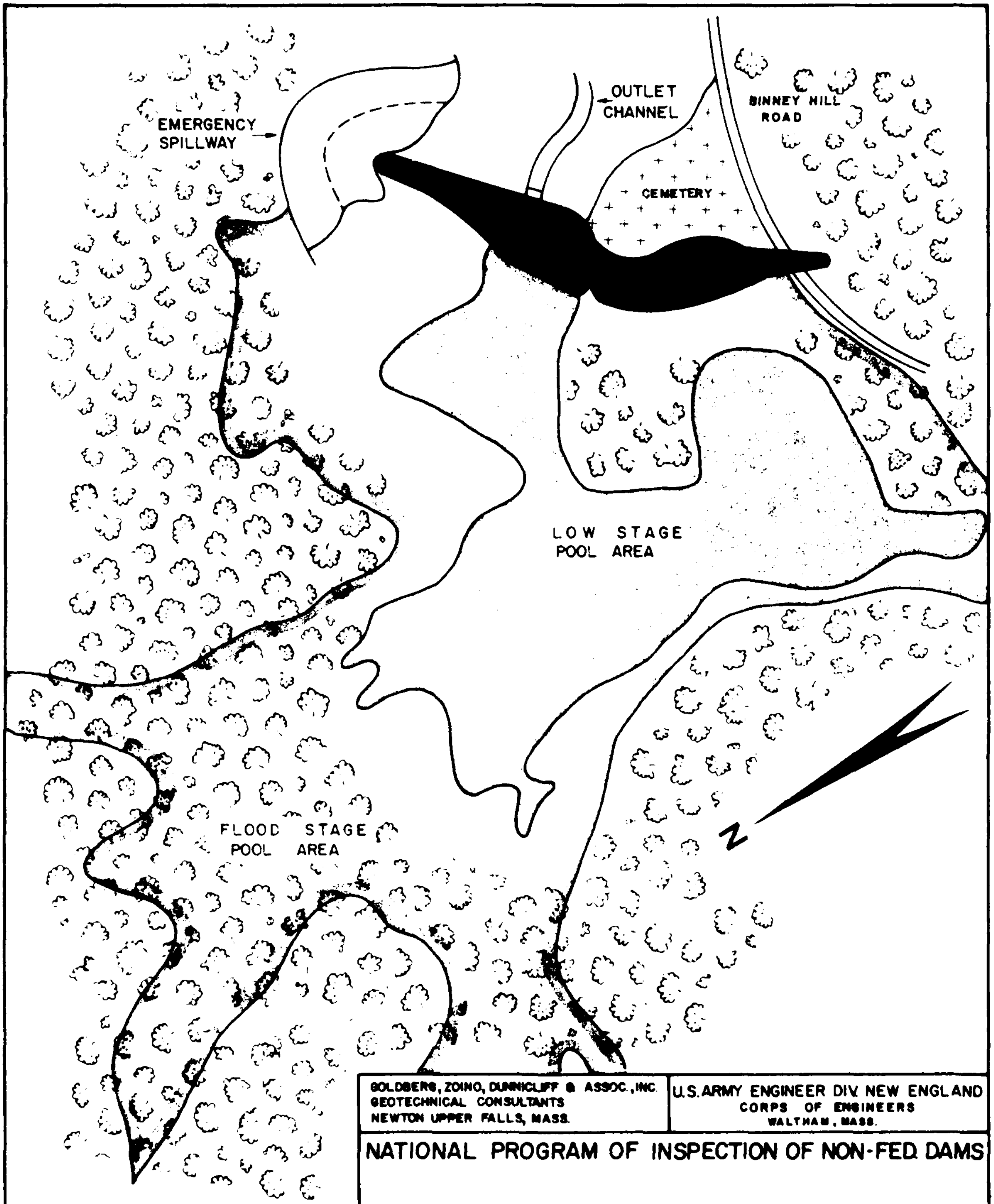


10. Detail of outlet pipe showing washed out joint filler

APPENDIX D

HYDROLOGIC/HYDRAULIC COMPUTATIONS

APPENDIX B



GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

SITE PLAN

SOUHEGAN RIVER WATERSHED
DAM No. 35

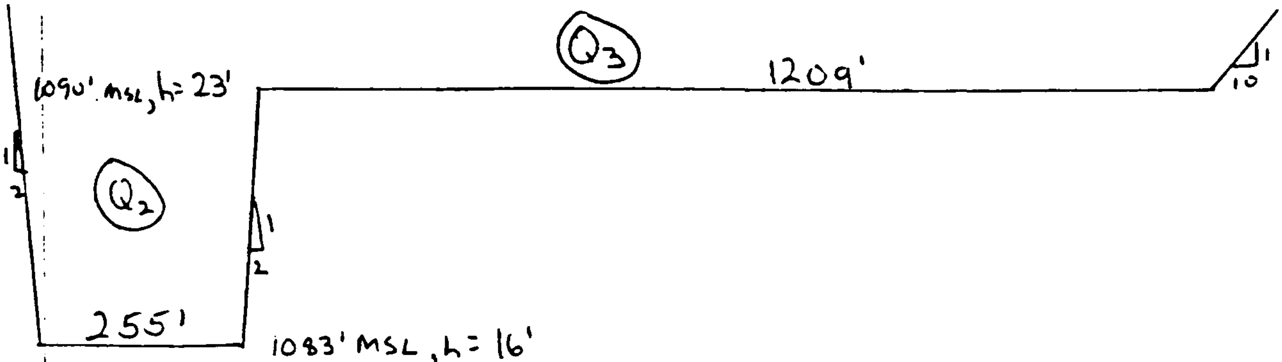
FILE No. 2327

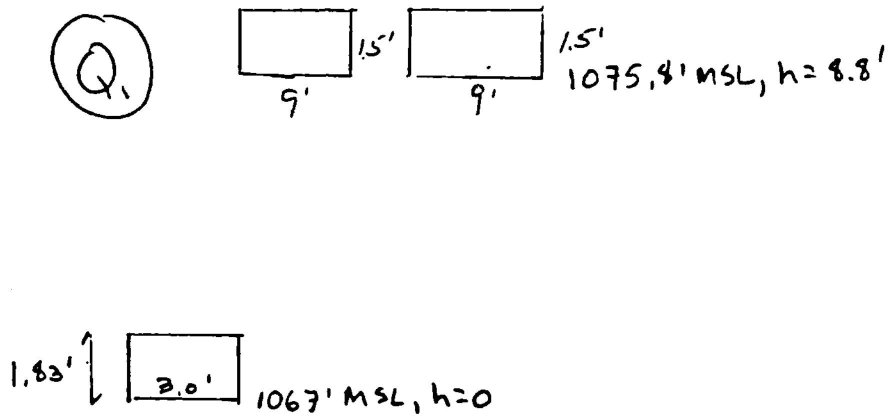
			SCALE	1" = 200'
			DATE	MAY 1979

142 Dam Safety S.R.W. Dam #35 TCG, 5/15/79

Stage-Discharge Curve

Information for the elevation of this dam is from Soil Conservation Service As-Built plans.





The lower orifice (1.83' x 3.0') & 2 higher orifices are on a riser structure located in the reservoir. Normal pool elevation is at the orifice crest, 1067' MSL.

flows:

Q1 Q_1 is the total of orifice

flows. These flows combine in the riser and flow under the dam through a 36" pipe. The combined flow is the principal spillway flow. At high stages the 36" pipe becomes the control to flow.

Lower Orifice flow (Q_o)

for $h < 1.83'$

$$Q_o = 3.4(3.00)\,H^{3/2}$$

$$= 10.2\,H^{3/2} \qquad H = h$$

$$= 10.2\,h^{3/2}$$

3.4 = Weir coefficient, p.4-8 of SCS Design Calcs.

for $h > 1.83$

$$Q_o = CA\sqrt{2gH}$$

$$C = .6,\ A = (1.83)(3) = 5.49,\ H = h - \frac{1.83}{2} = h - .92$$

$$Q_o = .6(5.49)\sqrt{2g}\,(h-.92)^{1/2}$$

$$= 26.43\,(h-.92)^{\frac{1}{2}}$$

Upper Weir flow (Q_w)

for $h < 8.8'$

$$Q_w = 0$$

for $8.8 < h$ 10.3

$$Q_w = 2(9')(3.3)H^{3/2} \quad , H = h - 8.8$$

3.3 = Weir coefficient, p4-8 of SCS Design calculations

$Q_w = 59.4(h-8.8)^{3/2}$

Pipe flow

$$Q_p = K A_p \sqrt{2gH}$$

where

$A_p = \pi(1.5)^2 = 7.07$ ft^2 = area of pipe

$$K = \frac{1}{\sqrt{k_o + k_r + k_p L_p}}$$

$k_o = 1.0$

$K_r = 1.5$

$k_p = .00616$

P. 4-6, SCS design calcs

$L_p = 160.6'$ (As built plans)

$$\rightarrow K = \frac{1}{\sqrt{1+1.5+.00616(160.6)}} = \frac{1}{\sqrt{1+1.5+.989}}$$

$= .535$

$$Q_p = K A_p \sqrt{2g}\, H^{\frac{1}{2}} = .535(7.07)\sqrt{2g}\; H^{\frac{1}{2}}$$

$= 30.37\ H^{\frac{1}{2}}$, H = head above tailwater surface

Tailwater surface = 1062.0' MSL from SCS design calculations, p. 4-5. (This is an estimate to

establish H for spillway) 1062.0 is = h = -5.0
(5 ft. below the crest of the low flow outlet.

so $Q_P = 30.37\,(h+5.0)^{\frac{1}{2}}$

Principal Spillway outflow, Q_1 is equal to the lower flow of $Q_0 + Q_W$ vs. Q_P for a given stage. Thus:

$0 \le h \le 1$

$Q_1 = 10.2\,h^{3/2}$

or $Q_1 = 30.37\,(h+5.0)^{\frac{1}{2}}$ whichever is smaller

$1 \le h \le 8.8$

$Q_1 = 26.43\,(h-.92)^{\frac{1}{2}}$

or $Q_1 = 30.37\,(h+5.0)^{\frac{1}{2}}$ whichever is smaller

$h > 8.8$ up to $h = 10.3$. Above h = 10.3, Q = 30.37, etc.

$Q_1 = 26.43\,(h-.92)^{\frac{1}{2}} + 59.4\,(h-8.8)^{3/2}$

or $Q_1 = 30.37\,(h+5.0)^{\frac{1}{2}}$ whichever is smaller

Q_2, Emergency Spillway flow.

up to elevation 1089.96 Ft. MSL, the SCS developed a stage-Discharge curve for this dam. This curve is given on p. 4-12 of their Design

Calculations. The computations consider head loss in the grass-lined channel leading to the emergency spillway, and calculate discharge based on the head at the spillway control section:

SCS Design Calculations

Pool elevation (Ft. MSL)	h (Ft. above 1067.0)	Stage above emergency spillway Crest (Ft)	Discharge through em. spill. (CFS)
1083	16	0	0
1083.96	16.96	.96	512
1084.43	17.43	1.43	1026
1084.80	17.80	1.80	1543
1085.18	18.18	2.18	2060
1085.43	18.43	2.43	2579
1086.26	19.26	3.26	3883
1086.91	19.91	3.91	5193
1087.50	20.50	4.50	6510
1088.05	21.05	5.05	7833
1089.09	22.09	6.09	10,496
1089.96	22.96	6.96	13,180

Linear interpolation from these values was used to determine the flow at h = 16, 17, 18, ..., 22, etc.

Pool elevation (Ft. MSL)	h (Ft. Above 1067.0)	Stage above Emergency Spillway Crest (Ft)	Discharge Through Emergency Spillway (CFS)
1083	16	0	0
1084	17	1	556
1085	18	2	1815
1086	19	3	3474
1087	20	4	5430
1088	21	5	7713
1089	22	6	10,766

It was also necessary to extend the stage-Discharge curve above the top of the dam. (1090' MSL, h=23'). For this we used SCS Technical Release 39, "The Hydraulics of Broad-crested spillways."

For spillway we assumed:

$n = .04$

b = width = 255'

z = side slope = 2 (2:1)

spillway head loss can be approximated as a case 8 spillway

L = length from pool to end of control section = 430'

This gave these results.

elevation (Ft. MSL)	h (stage above 1067')	Hp (stage above em. spillway crest, Ft.)	Hec * (Total Head at em. spill crest, Ft)	Discharge ** (CFS)
1090	23	7	6.	12,900
1091	24	8	7.25	16,000
1092	25	9	9.05	19,500

* given by Figure ES-171, sheet 8 of 10, in SCS TR-39. This figure plots Hec vs. Hp. for given L, & n = .04. The figure is valid for Case 8 spillways, to which this is similar. The Hec vs. Hp relationship does not vary significantly with b for $0 \le b \le 1000$.

** ES-174, sheet 9 of 9 in SCS TR-39. This figure give Q for given Hec, b, if z = 2.

(Q3) flow over Dam.

for h < 23,

$Q3 = 0$

for h > 23

$$Q3 = 2.6\,(1209)(h-23)^{3/2} + 2.6(10)(h-23)(.5(h-23))^{3/2}$$

c = 2.6 for broad-crested earth weir with grass

This represents a 1209' weir with a 10:1 side slope on one side. Flow on the other side is included with the emergency spillway.

PP. 9, 10, 11, & 12 give qBasic program to calculate a stage-Discharge Relationship for this dam.

```
LIST
100 REM - STAGE/DISCHARGE CURVE FOR SOUHEGAN RIV. WATERSHED DAM # 35
110 REM - STORED ON TAPE B-1 FILE 2
120 PAGE
130 REM - THE D1 ARRAY CONTAINS EMERGENCY SPILLWAY OUTFLOW DATA
140 DIM D1(25)
150 DATA 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,556,1815,3474,5430,7713,10260
160 DATA 12900,16000,19500
170 READ D1
180 PRINT USING 190:
190 IMAGE 10T"DISCHARGE FOR SOUHEGAN RIVER WATERSHED DAM NUMBER 35"
200 PRINT USING 210:
210 IMAGE 10T"   AS A FUNCTION OF HEAD ABOVE THE LOW FLOW OUTLET"
220 PRINT USING 230:
230 IMAGE // 2T"HEAD"3X"ELEVATION"30T"DISCHARGE"
240 PRINT USING 250:
250 IMAGE 1T"(FEET)"2X"(FT. MSL)"32T"(CFS)"
260 PRINT USING 270:
270 IMAGE 22T "TOTAL        PRINCIPAL        EMERGENCY        TOP OF DAM"
280 PRINT USING 290:
290 IMAGE 22T "             SPILLWAY         SPILLWAY"
300 FOR H=0 TO 25
310 Q1=0
320 Q2=0
330 Q3=0
340 Q4=0
350 REM - Q4 IS THE LOW FLOW OUTLET (ORIFICE) FLOW
360 Q5=0
370 REM - Q5 IS THE HIGH STAGE OUTLET (WEIRS) FLOW
380 Q6=0
390 REM - Q6 IS THE PIPE FLOW
400 Q4=10.2*H↑1.5
410 IF H<1.83 THEN 550
420 Q4=26.43*(H-0.92)↑0.5
430 IF H<8.8 THEN 550
```

P 9

P 10

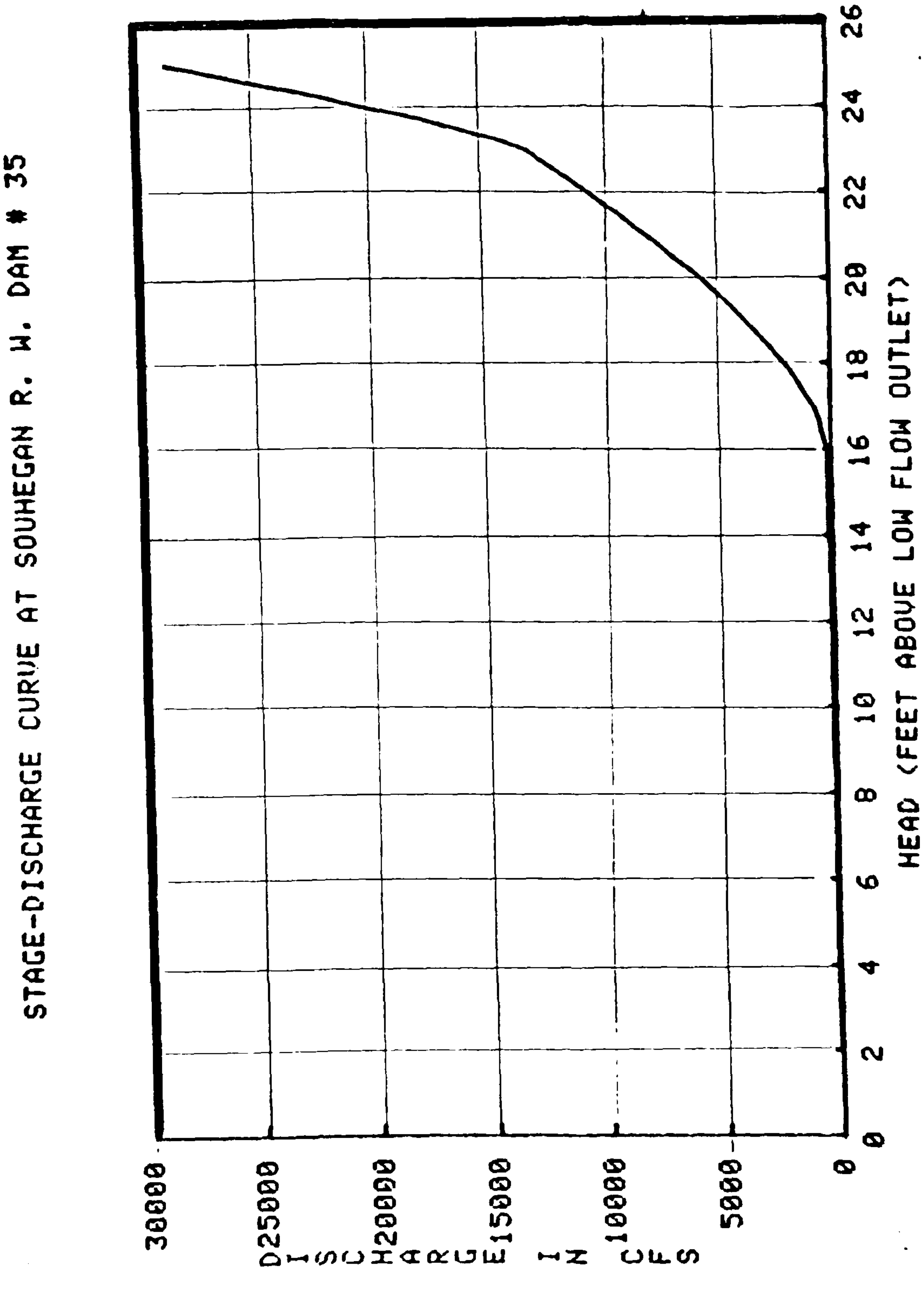
```
440 Q5=59.4*(H-0.92)↑1.5
450 IF H<16 THEN 550
460 REM - THE EMERGENCY SPILLWAY FLOW (Q2) IS DETERMINED BY LINEAR
470 REM -    INTERPOLATION OF THE VALUES IN ARRAY D1.
480 IF INT(H)<25 THEN 520
490 REM - LINEAR EXTRAPOLATION BEYOND D1 CURVE
500 Q2=D1(25)+(H-25)*(D1(25)-D1(24))
510 GO TO 530
520 Q2=D1(INT(H))+(-D1(INT(H))+D1(INT(H)+1))*(H-INT(H))
530 IF H<=23 THEN 550
540 Q3=2.6*1209*(H-23)↑1.5+2.6*10*(H-23)*(0.5*(H-23))↑1.5
550 Q1=Q4+Q5
560 Q6=30.37*(H+5)↑0.5
570 REM - THE LOWER VALUE OF Q6 VS. Q4+Q5 IS CONTROLLING.
580 IF Q1<Q6 THEN 600
590 Q1=Q6
600 T1=Q1+Q2+Q3
610 E=H+1067
620 PRINT USING 630:H,E,T1,Q1,Q2,Q3
630 IMAGE 1T,3D.1D,8D.1D,13D,13D,13D,13D
640 NEXT H
650 END
```

P. 11

DISCHARGE FOR SOUHEGAN RIVER WATERSHED DAM NUMBER 35
AS A FUNCTION OF HEAD ABOVE THE LOW FLOW OUTLET

HEAD (FEET)	ELEVATION (FT. MSL)	DISCHARGE (CFS) TOTAL	PRINCIPAL SPILLWAY	EMERGENCY SPILLWAY	TOP OF DAM
0.0	1067.0	0	0	0	0
1.0	1068.0	10	10	0	0
2.0	1069.0	27	27	0	0
3.0	1070.0	38	38	0	0
4.0	1071.0	46	46	0	0
5.0	1072.0	53	53	0	0
6.0	1073.0	60	60	0	0
7.0	1074.0	65	65	0	0
8.0	1075.0	70	70	0	0
9.0	1076.0	114	114	0	0
10.0	1077.0	119	118	0	0
11.0	1078.0	121	121	0	0
12.0	1079.0	125	125	0	0
13.0	1080.0	129	129	0	0
14.0	1081.0	132	132	0	0
15.0	1082.0	136	136	0	0
16.0	1083.0	139	139	0	0
17.0	1084.0	698	142	556	0
18.0	1085.0	1961	146	1815	0
19.0	1086.0	3623	149	3474	0
20.0	1087.0	5582	152	5430	0
21.0	1088.0	7863	155	7713	0
22.0	1089.0	10418	158	10260	0
23.0	1090.0	13061	161	12900	0
24.0	1091.0	19316	164	16000	3153
25.0	1092.0	28609	166	19500	8943

P 12


STAGE-DISCHARGE CURVE AT SOUHEGAN R. W. DAM # 35
HEAD (FEET ABOVE LOW FLOW OUTLET)
0 2 4 6 8 10 12 14 16 18 20 22 24 26
DISCHARGE IN CFS
0 5000 10000 15000 20000 25000 30000

Storage-Elevation Curve

The Storage-Elevation curve for Souhegan River Watershed Dam Number 35 is given on pp. 3-1 & 3-2 of the SCS Hydrologic and Hydraulic Design Calculations. The Curves include current storage and "available storage" after fifty years of sedimentation. Pp. 14 and 15 give a table and plot of storage vs. elevation.

1" of runoff over 4026 acres $= (1/12')(4026 \text{ Ac})$

$= 335.5$ Ac-Ft.

1 Ac-Ft. of storage $= \frac{1}{335.5} = .00298$" of runoff

1 ft. of rise (from h=0, 1067' MSL = normal pool to h=1, 1068' MSL) would store:

$.00298'' / \text{Ac-Ft.} \; (22 \text{ Ac-Ft}) = .066''$ of runoff

after 50 years of sedimentation.

Available storage to the emergency spillway crest is (851 ac-ft)(.00298) = 2.54" of runoff.

To the dam crest, available storage is (1718)(.00298) = 5.12" of runoff.

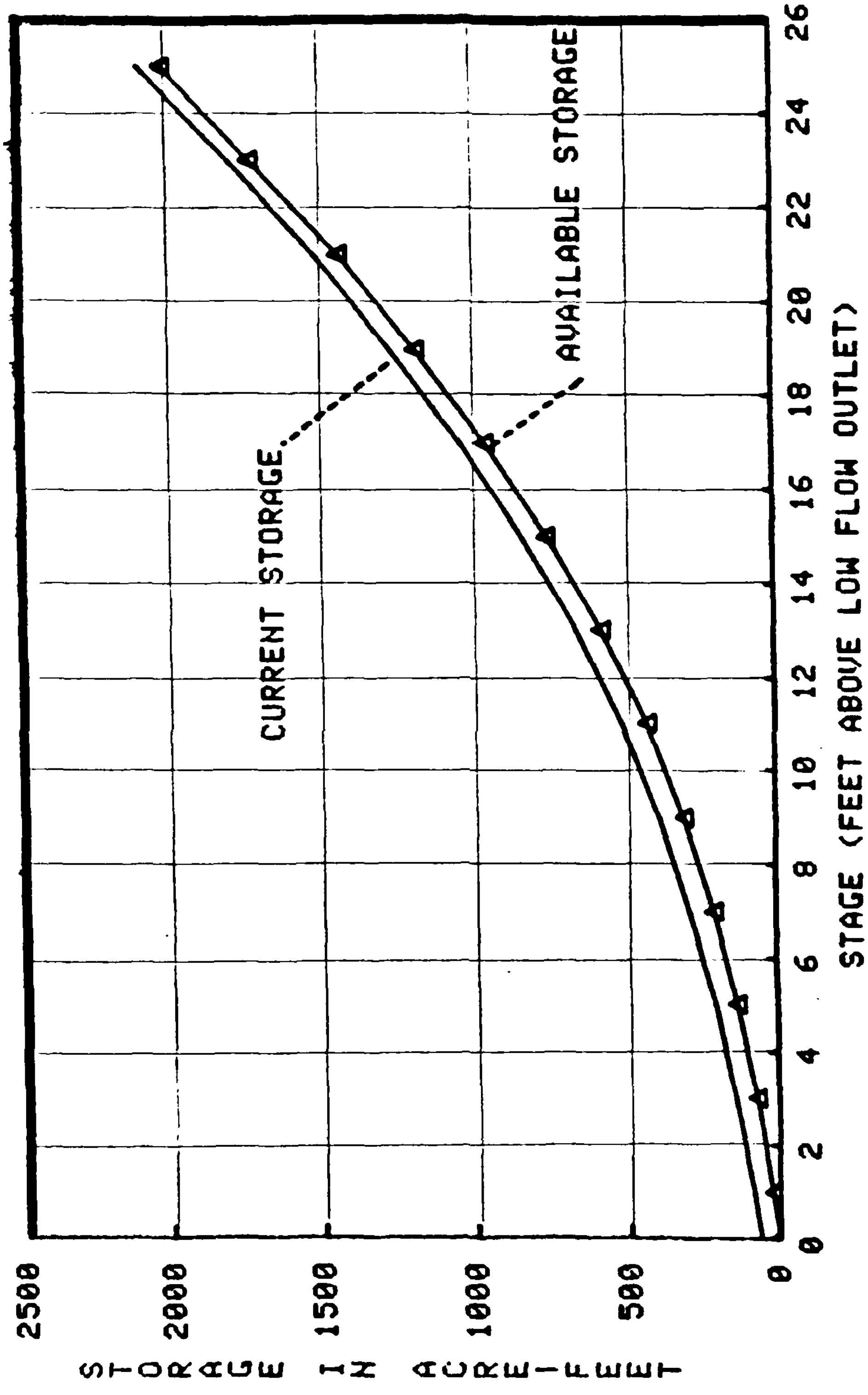
P. 14

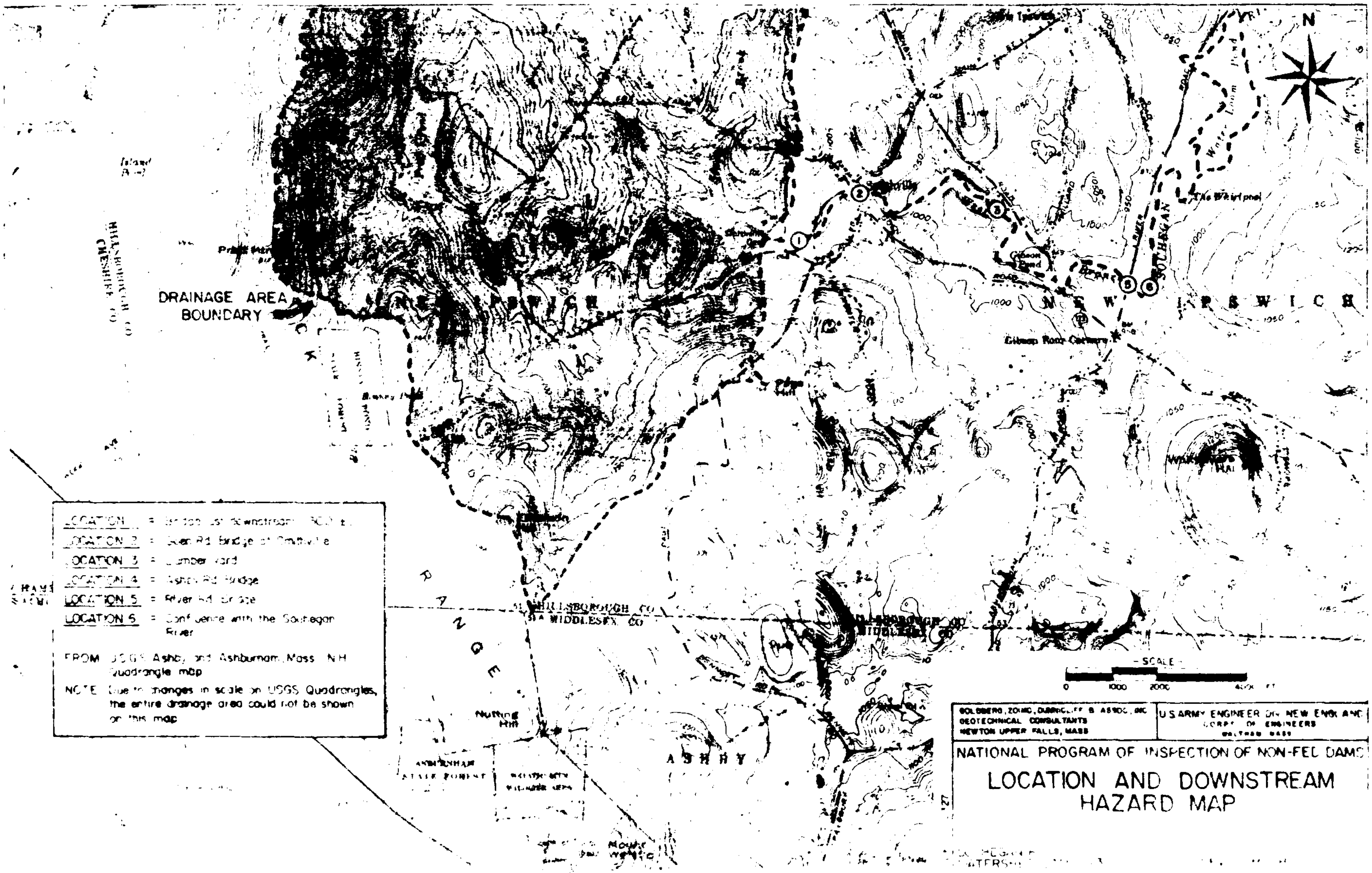
STORAGE ELEVATION CURVE FOR SOUHEGAN R. W. DAM # 35

ELEVATION (FT. MSL)	HEAD ABOVE LOW FLOW OUTLET (FEET)	CURRENT STORAGE (AC-FT)	AVAILABLE STORAGE (AC-FT)
1060.0	-7	0	0
1062.0	-5	1	0
1064.0	-3	11	0
1066.0	-1	42	0
1067.0	0	65	0
1068.0	1	88	22
1070.0	3	144	73
1072.0	5	211	135
1074.0	7	292	211
1076.0	9	392	310
1078.0	11	513	431
1080.0	13	658	577
1082.0	15	832	751
1084.0	17	1033	951
1086.0	19	1260	1179
1088.0	21	1511	1430
1090.0	23	1787	1718
1092.0	25	2086	2005

P. 15

STORAGE-ELEVATION CURVE AT SOUHEGAN R. W. DAM # 35




N
DRAINAGE AREA BOUNDARY
NEW IPSWICH
SOUHEGAN RIVER
The Whirlpool
Water Loom Pond
Gibson Pond
Gibson Road Cemetery
Smithville
RANGE
ASHBY
HILLSBOROUGH CO
MIDDLESEX CO
HILLSBOROUGH CO
CHESHIRE CO
Nutting Hill
ASHBURNHAM STATE FOREST
LOCATION 3 = Lumber Yard
LOCATION 4 = Ashby Rd Bridge
LOCATION 6 = Confluence with the Souhegan River
FROM USGS Ashby and Ashburnam, Mass. N.H. Quadrangle map
NOTE Due to changes in scale on USGS Quadrangles, the entire drainage area could not be shown on this map
SCALE
0 1000 2000 4000 FT
GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS
U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS
LOCATION AND DOWNSTREAM HAZARD MAP

Dam Failure Analysis

P. 16 is a location and Downstream Hazard Map for S.R.W.D. # 35.

The first question to be addressed is the assumed water surface elevation at dam failure. The normal assumption is that failure occurs at the top of the dam. This would yield a pre-failure outflow of 13,061 cfs. However, this flow is higher than the Soil Conservation Service' (S.C.S.) routed P.M.F. outflow for this reservoir. Also, this flow would create severe flooding downstream prior to dam failure. Dam Failure would have a greater incremental impact on flooding if it were to occur with a lower water surface elevation in the reservoir. Therefore, we will assume that Dam Failure occurs with the water surface elevation at S.C.S. Design High water, 1085.4' MSL, h=18.4 ft. This represents 2.4 ft. of flow in the emergency spillway.

183 Dam Safety Souhegan R. W. Dam #35 TCG, 5/30/79, p. 3

Normal flow at this elevation is 2625 cfs.

Peak failure outflow = Normal outflow + Breach outflow

Breach outflow:

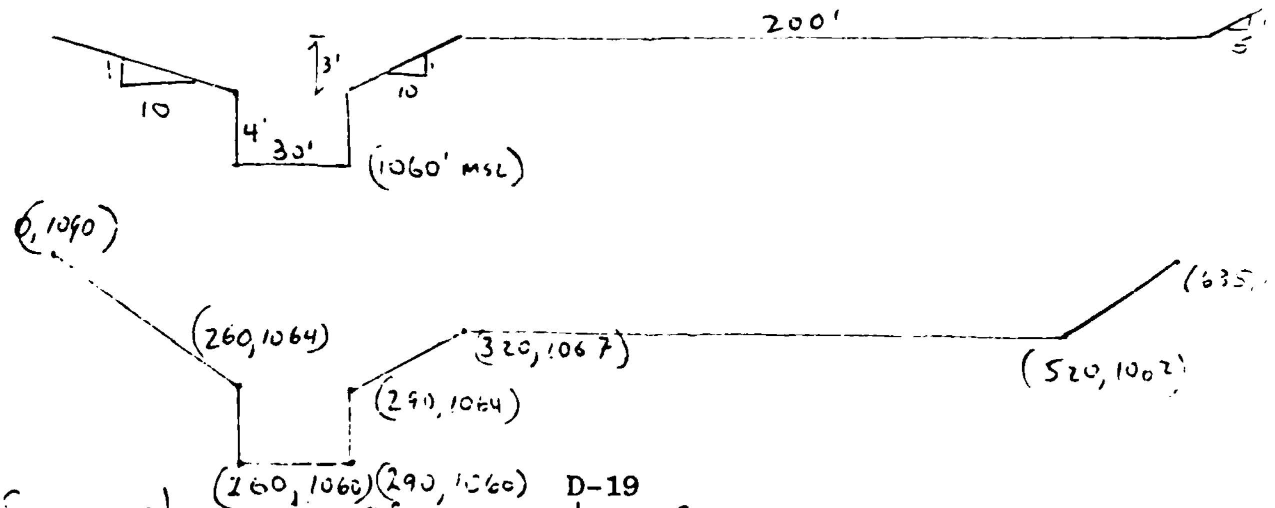
$$Q_{p1} = \frac{8}{27} \sqrt{g}\, W_b \left(Y_0\right)^{3/2}$$

where: W_b = breach width ≤ 40% of width at ½ ht. of dam.

from sheet 4 of the As-builts, width at ½ ht = 440' → W_b = .4(440) ≈ 180'

Y_0 = ht. above tailwater at failure.

The channel just downstream of S.R.W. Dam # 35 has approximately this cross-section (from field notes)



D-19

From sheet 4 of S.C.S. plans, S = .0133, n = .035

[illegible]

p. 19

DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.00	1060.0	0.0	0.0	0.0	0.0	0.0
1.00	1061.0	30.0	32.0	0.9	28.7	104.5
2.00	1062.0	60.0	34.0	1.8	87.6	318.8
3.00	1063.0	90.0	36.0	2.5	165.8	603.2
4.00	1064.0	120.0	38.0	3.2	258.4	939.9
5.00	1065.0	160.0	58.1	2.8	314.5	1143.8
6.00	1066.0	220.0	78.2	2.8	438.6	1595.3
7.00	1067.0	300.0	98.3	3.1	631.4	2296.7
8.00	1068.0	597.5	313.4	1.9	918.8	3341.9
9.00	1069.0	910.0	328.6	2.8	1795.2	6529.6
10.00	1070.0	1237.5	343.7	3.6	2908.1	10577.5
11.00	1071.0	1580.0	358.9	4.4	4246.2	15444.6
12.00	1072.0	1937.5	374.0	5.2	5803.5	21109.2
13.00	1073.0	2310.0	389.2	5.9	7577.1	27560.1
14.00	1074.0	2697.5	404.3	6.7	9565.6	34793.0
15.00	1075.0	3100.0	419.5	7.4	11769.1	42807.9
16.00	1076.0	3517.5	434.6	8.1	14188.6	51608.3
17.00	1077.0	3950.0	449.8	8.8	16825.6	61199.9
18.00	1078.0	4397.5	464.9	9.5	19682.1	71589.9
19.00	1079.0	4860.0	480.1	10.1	22760.6	82787.1
20.00	1080.0	5337.5	495.2	10.8	26063.5	94801.0
21.00	1081.0	5830.0	510.4	11.4	29593.9	107642.0
22.00	1082.0	6337.5	525.5	12.1	33354.7	121321.3
23.00	1083.0	6860.0	540.7	12.7	37349.1	135850.1
24.00	1084.0	7397.5	555.8	13.3	41580.3	151240.4
25.00	1085.0	7950.0	571.0	13.9	46051.8	167504.3
26.00	1086.0	8517.5	586.1	14.5	50766.7	184654.1
27.00	1087.0	9100.0	601.3	15.1	55728.7	202702.4
28.00	1088.0	9697.5	616.4	15.7	60941.2	221661.8
29.00	1089.0	10310.0	631.6	16.3	66407.8	241545.2
30.00	1090.0	10937.5	646.7	16.9	72131.8	262365.4

Stage- Normal Flow Relationship for Tailwater, S.R.W. Dam #35

At 2625 cfs, the tailwater is at about 1067.3 msl.

$y_o = 1085.4 - 1067.3 \simeq 18.1'$

$Q_{P_1} = 8/27 \sqrt{g}\ 180 (18.1)^{3/2} = 23,304$ cfs

So peak failure outflow = 23,304 + 2625 $\simeq$ 26,000 cfs

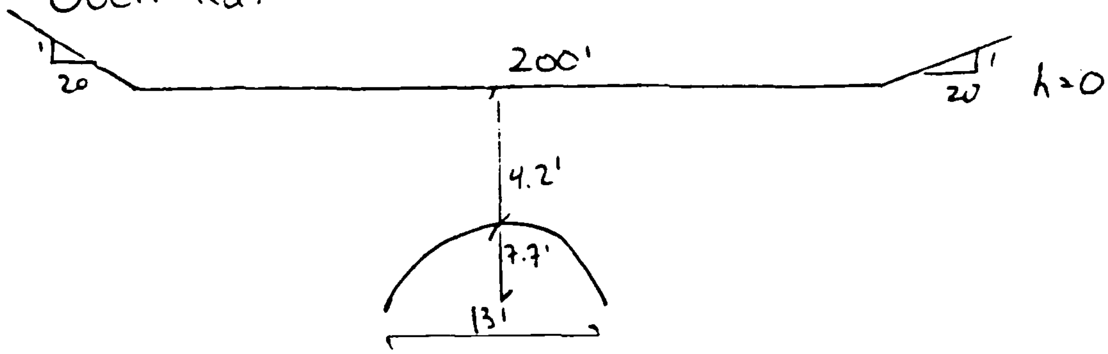
This would raise the tailwater to 1072.8' msl, an increase of 5.5'.

The first location effected would be the Binney Hill Road Bridge just downstream of the dam (300' ±). The failure outflow of 26,000 cfs would overtop and probably severely damage this bridge.

The West Branch of the Souhegan River proceeds through a linked series of ponds about 2300' from the dam to Smithville. At Smithville, the Branch passes through a culvert under Goen Rd. Bridge. About 50 ft. downstream of the bridge is a dam, which creates a pool extending under Goen Rd. The village of Smithville consists of 10-15 houses, of which two are upstream of Goen Rd. on the pond and one more just downstream of Goen Rd.

At high flows, the water level upstream of Goen Rd is controlled by the road embankment and culvert.

Goen Rd:



The flow through the culvert is estimated from FHWA Hydraulic Engineering Circular #5.

$$Q_{road} = 3(200)h_{rd}^{3/2} + \left[3(20)(h)(.5(h))^{3/2}\right]2$$

from the weir equation with C=3.0 for a broadcrested concrete weir.

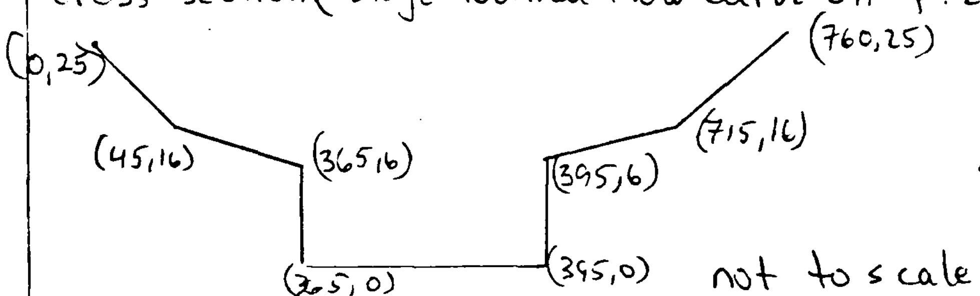
h (over rd) (ft)	$Q_{culvert}$ (cfs)	Q_{road} (cfs)	Total Flow (cfs)
0	990	0	990
1	1080	640	1720
2	1160	1940	3100
3	1220	3780	5000
4	1280	6160	7440
5	1330	9080	10,410
6	1380	12,560	13,940
7	1430	16,610	18,040
8	1480	21,260	22,740
9	1530	26,510	28,040
10	1580	32,390	33,970

Thus, before failure the water surface would be about 1.7 ft. above the rd. (13.6 ft. above streambed) To determine water surface after failure, it is necessary to include attenuation. To do so, we will assume a surface area of 20 acres upstream of Goen Rd. Thus surcharge storage = (h-1.7) 20. P. 23 gives the determination of attenuated peak failure outflow at Smithville.

The attenuated peak is 22,800 cfs, which yields at water surface 8 ft. above Goen Rd. (19.9 ft. above the streambed). This assumes that the Goen Rd. embankment holds. In fact, it might well fail under a flow of this magnitude. However, the failure would not change flood levels in this area significantly. The channel is constricted in this area, and about 100 ft. downstream of Goen Rd. it enters a narrow, rocky gorge. The fact that the natural channel changes from a wide floodplain to a narrow, steep-sided gorge is the primary source of the high stages in this area.

The two houses on the pond upstream of Goen Rd. are approximately at the level of the roadway. Thus, dam failure would raise flooding at these houses from 1.7 feet to 8 feet, which would present a serious threat to property and to life. The house downstream, which is at the road level, would also receive serious flooding. Other houses in Smithville might also experience some flooding, although at levels much below eight feet.

The next area of concern downstream of Smithville is a lumberyard about 3800 ft. downstream. The reach between Smithville and this lumber yard has this as a typical cross-section (Stage-Normal Flow curve on p. 24):



$n = .040$

slope $= .0083$

Attenuated Failure Outflow at Smithville

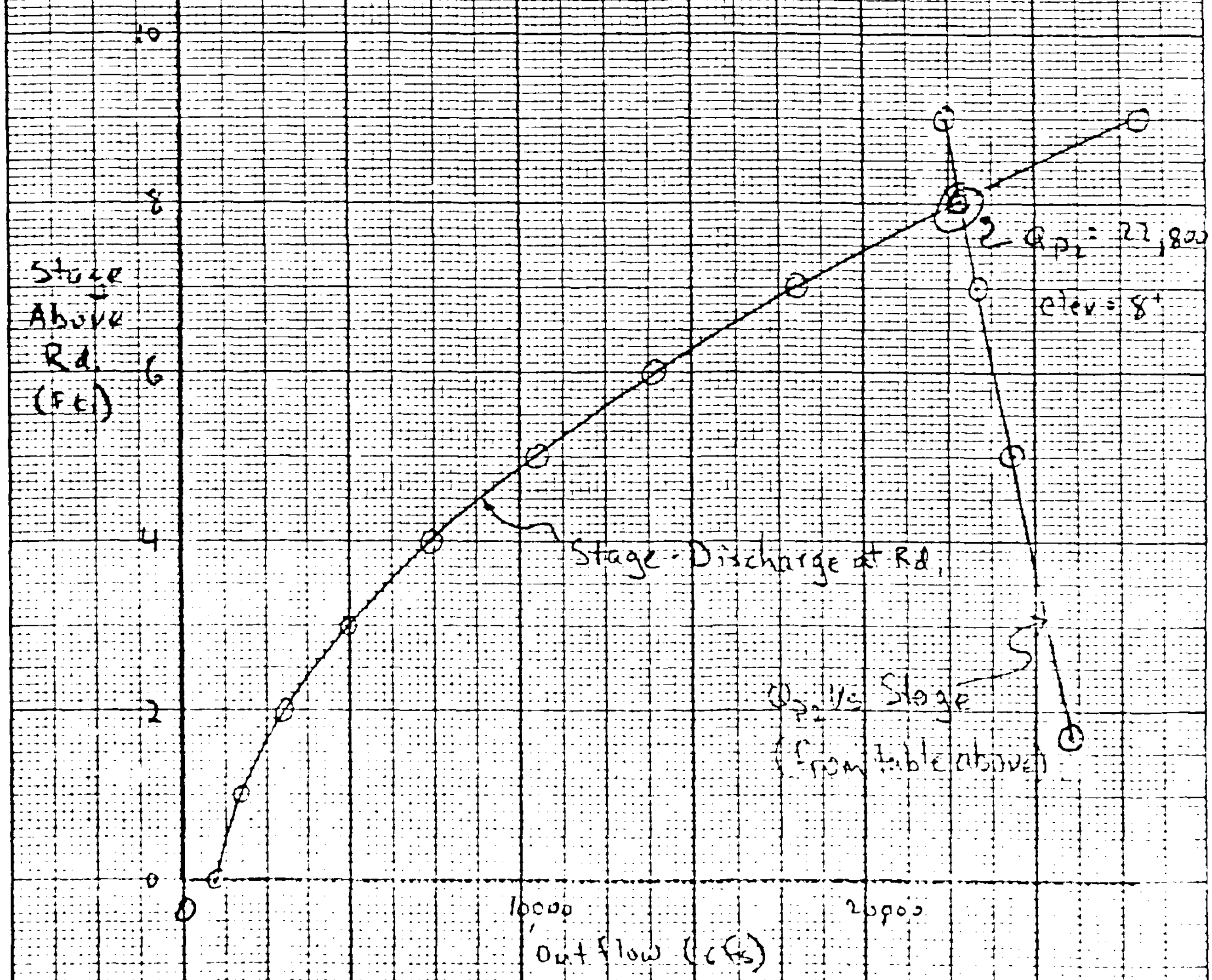
TCG
5/31/79 - 23

$Q_{p_2} = Q_{p_1}\left(1 - \frac{stor}{1068}\right)$ stor in ac-ft

1068 = storage at Design high water

$= 26{,}000\left(1 - \frac{stor}{1068}\right)$

Q_{p_2}	elev.	stor. (above L=1.3)
26000	1.7	0
24,400	5	66
22,450	9	146
22,900	8	126
23,400	7	106



DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.00	0.0	0.0	0.0	0.0	0.0	0.0
1.00	1.0	30.0	32.0	0.9	28.7	97.5
2.00	2.0	60.0	34.0	1.8	87.6	297.4
3.00	3.0	90.0	36.0	2.5	165.8	562.8
4.00	4.0	120.0	38.0	3.2	258.4	876.9
5.00	5.0	150.0	40.0	3.8	362.2	1229.2
6.00	6.0	180.0	42.0	4.3	475.2	1612.5
7.00	7.0	242.0	106.0	2.3	419.6	1424.0
8.00	8.0	368.0	170.1	2.2	615.8	2089.9
9.00	9.0	558.0	234.1	2.4	996.0	3380.0
10.00	10.0	812.0	298.1	2.7	1584.2	5376.2
11.00	11.0	1130.0	362.2	3.1	2413.8	8191.5
12.00	12.0	1512.0	426.2	3.5	3518.6	11940.8
13.00	13.0	1958.0	490.2	4.0	4931.3	16735.1
14.00	14.0	2468.0	554.2	4.5	6683.2	22680.5
15.00	15.0	3042.0	618.3	4.9	8804.5	29879.3
16.00	16.0	3680.0	682.3	5.4	11324.0	38429.7
17.00	17.0	4355.0	692.5	6.3	14846.7	50384.2
18.00	18.0	5040.0	702.7	7.2	18756.5	63652.9
19.00	19.0	5735.0	712.9	8.0	23041.1	78193.0
20.00	20.0	6440.0	723.1	8.9	27690.2	93970.4
21.00	21.0	7155.0	733.3	9.8	32695.7	110957.2
22.00	22.0	7880.0	743.5	10.6	38050.9	129130.8
23.00	23.0	8615.0	753.7	11.4	43750.2	148472.1
24.00	24.0	9360.0	763.9	12.3	49788.9	168965.5
25.00	25.0	10115.0	774.1	13.1	56163.3	190597.7

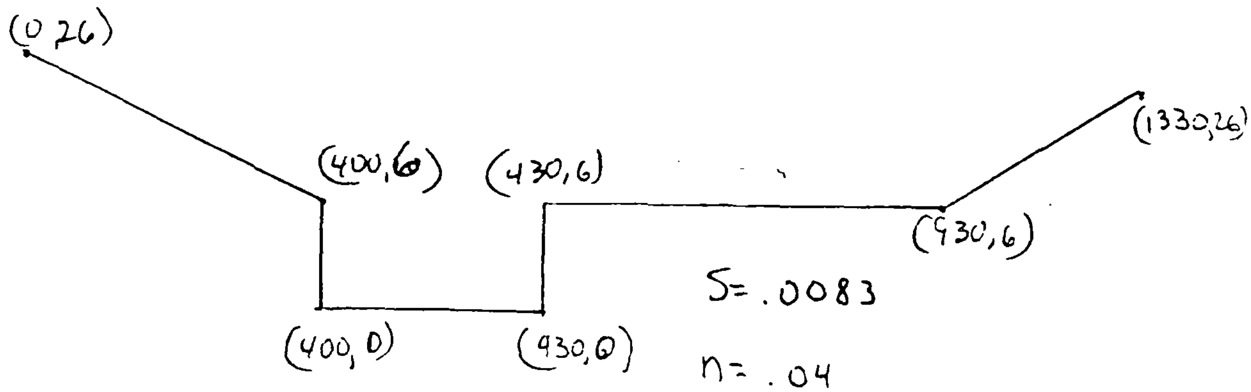
STAGE - NORMAL FLOW RELATIONSHIP FOR REACH D/S OF SMITHVILLE (TO LUM.YD)

P. 24

The pre-failure flow of 2625 cfs would yield 8.4 ft. of flow in the channel. To determine the water surface after failure, it is necessary to include attenuation. To do so, we will use the increase in channel area multiplied by the channel length of 3800'.

The attenuated peak is 19,500 cfs, which yields an elevation 13.5 ft above the stream bed. The lumber yard is about 12 ft. above the stream bed, and so would experience some flooding after dam failure. This might damage lumber stored in the yard although the structures are higher & would not be reached.

The next damage location downstream is Ashby Rd. Bridge, some 2800' downstream. The cross-section through this reach is approximately this;



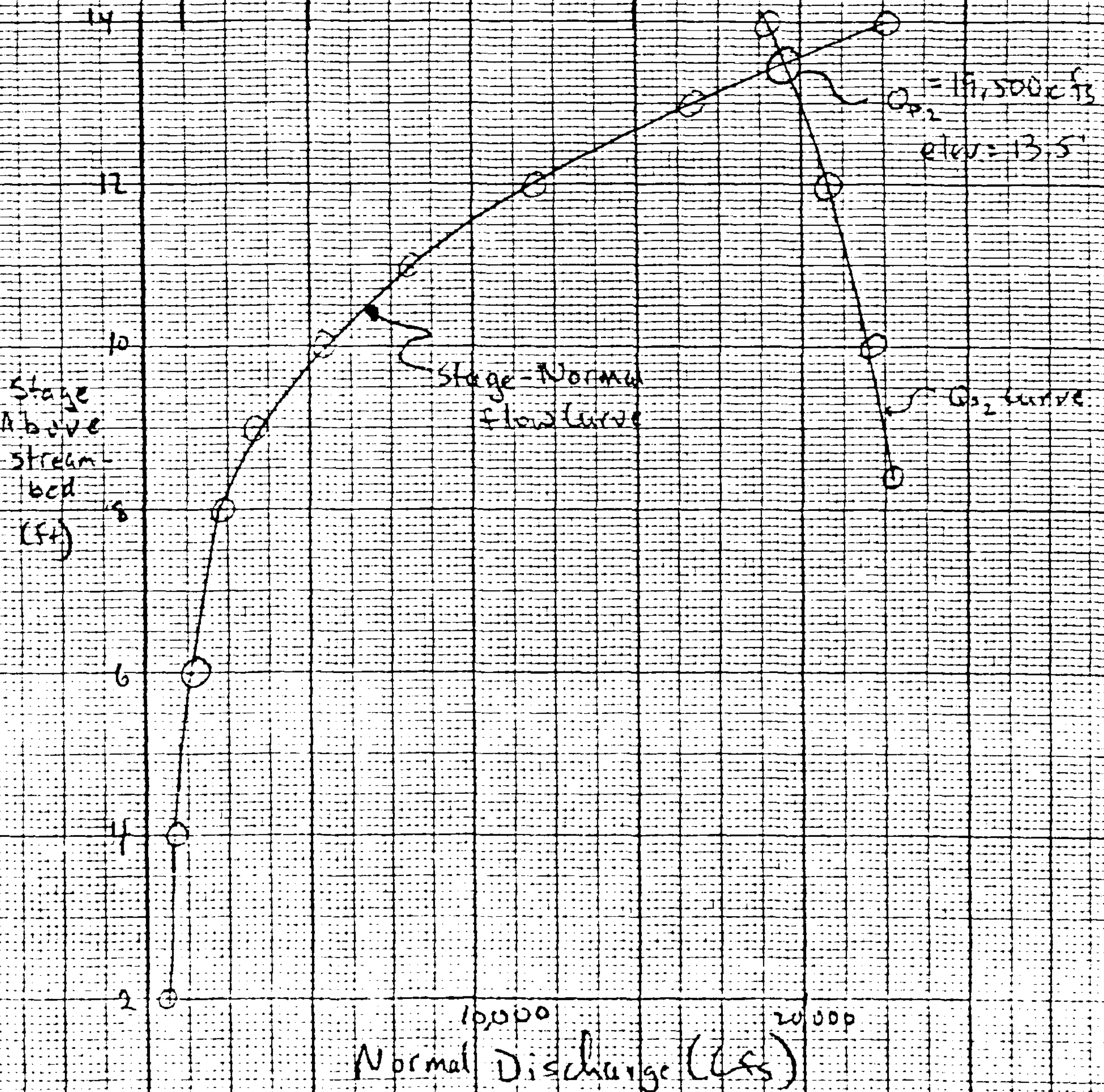
The Stage-Normal Flow curve for this cross-section is given on p. 27. Although Ashby Rd. Bridge does provide a constriction to flow, it is unlikely to cause significant back water effects at the flows we are considering, which would probably cause major damage to or failure of the bridge.

Attenuated Failure Outflow at Lumber Yard TCE, 5/31/79 p. 26

$$Q_{p_2} = Q_{p_1}\left(1 - \frac{Stor}{1068}\right)$$

$$= 22,800\left(1 - \frac{Stor}{1068}\right)$$

elev. (ft)	Area above 8.4 ft (ft²)	Storage $\left(\frac{Area \cdot 8900}{43560}\right)$ (ac-ft)	Q_{p_2}
8.4	0	0	22,800
10	368	32	22,100
12	1068	93	20,800
14	2024	177	19,000



DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.00	0.0	0.0	0.0	0.0	0.0	0.0
1.00	1.0	30.0	32.0	0.9	28.7	97.5
2.00	2.0	60.0	34.0	1.8	87.6	297.4
3.00	3.0	90.0	36.0	2.5	165.8	562.8
4.00	4.0	120.0	38.0	3.2	258.4	876.9
5.00	5.0	150.0	40.0	3.8	362.2	1229.2
6.00	6.0	180.0	42.0	4.3	475.2	1612.5
7.00	7.0	730.0	582.0	1.3	849.0	2881.4
8.00	8.0	1320.0	622.1	2.1	2180.2	7398.7
9.00	9.0	1950.0	662.1	2.9	4007.8	13601.1
10.00	10.0	2620.0	702.2	3.7	6305.5	21398.5
11.00	11.0	3330.0	742.2	4.5	9062.7	30755.5
12.00	12.0	4090.0	782.3	5.2	12277.0	41663.5
13.00	13.0	4870.0	822.3	5.9	15950.3	54129.4
14.00	14.0	5700.0	862.4	6.6	20087.5	68169.6
15.00	15.0	6570.0	902.4	7.3	24695.3	83806.9
16.00	16.0	7480.0	942.5	7.9	29781.6	101068.0
17.00	17.0	8430.0	982.5	8.6	35355.3	119982.9
18.00	18.0	9420.0	1022.6	9.2	41425.6	140583.6
19.00	19.0	10450.0	1062.6	9.8	48002.6	162903.3
20.00	20.0	11520.0	1102.7	10.4	55096.3	186976.8
21.00	21.0	12630.0	1142.7	11.1	62717.1	212839.1
22.00	22.0	13780.0	1182.8	11.7	70875.6	240526.0
23.00	23.0	14970.0	1222.8	12.2	79582.4	270073.7
24.00	24.0	16200.0	1262.9	12.8	88848.2	301518.4
25.00	25.0	17470.0	1302.9	13.4	98683.7	334896.7
26.00	26.0	18790.0	1343.0	14.0	109099.8	370245.1

STAGE - NORMAL FLOW RELATIONSHIP FOR REACH FROM LUMBER YD. TO ASHBY RD.

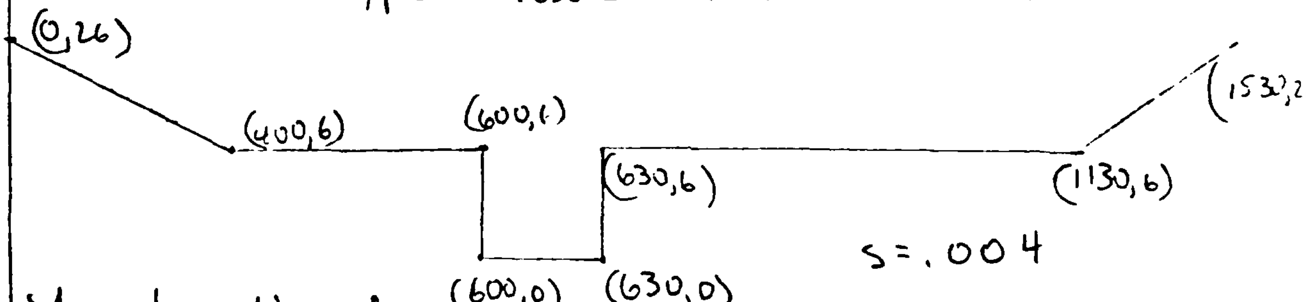
P. 27

The pre-failure flow of 2625 cfs would yield water at 6.8 ft. To determine the water surface after failure, it is necessary to include attenuation. To do so, we will use the increase in water area multiplied by the channel length of 2800' (see p. 29)

The attenuated peak is 17,500 cfs, which yields an elevation of 9.5 ft. above the streambed. There are no dwellings in this reach. Just downstream of Ashby Rd. there is one house, with a garage apartment which is about 2 feet below the road, 10 feet above the stream bed. It is possible that this house would be damaged by the Dam Failure outflow, but flooding would probably be minimal.

From the Ashby Rd. bridge, the stream proceeds about 3400' to the Souhegan River. The West Branch passes under River Rd. through two 6' c.m.p. culverts in this reach. At the flows we are considering, River Rd. would be seriously overtopped and probably washed out.

Here is a typical cross-section for this reach:



s = .004

n = .04

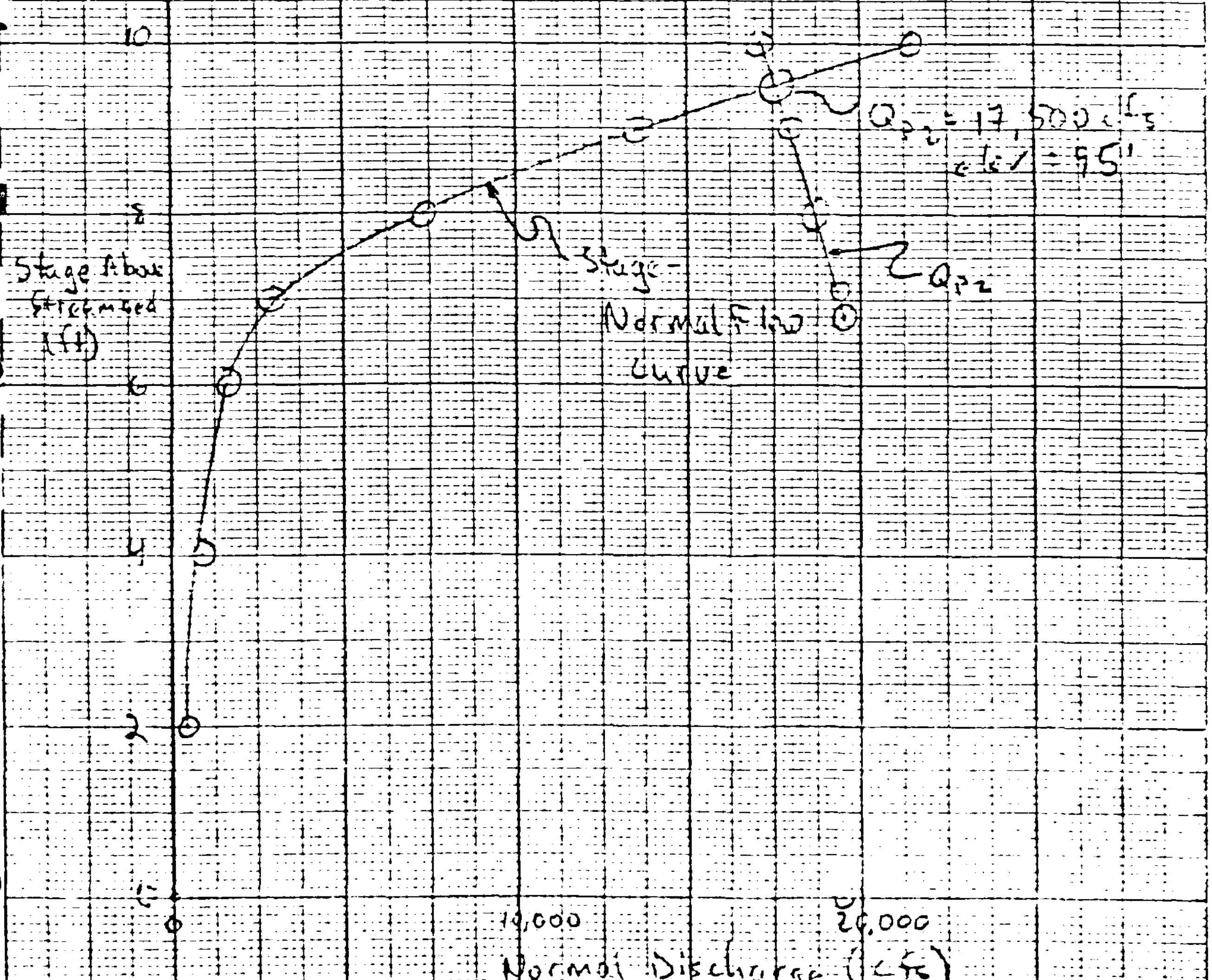
The stage-Normal Flow Relationship is given on p. 30

Attenuated Flow at Ashby Rd.   TCG, 5/31/79, p 29

$$Q_{p_2} = Q_{p_1}\left(1 - \frac{Stor}{1064}\right)$$

$$= 19{,}500\left(1 - \frac{Stor}{1064}\right)$$

elev. (ft)	Area (above 6.8 ft) (ft²)	Storage (Area · 2800 / 43560) (Ac-ft)	Q_{p_2} (cfs)
6.8	0	0	19,500
7	110	7.1	19,370
8	700	45	18,700
9	1330	85.5	17,900
10	2000	129	17,100



DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.00	0.0	0.0	0.0	0.0	0.0	0.0
1.00	1.0	30.0	32.0	0.9	28.7	67.7
2.00	2.0	60.0	34.0	1.8	87.6	206.5
3.00	3.0	90.0	36.0	2.5	165.8	390.7
4.00	4.0	120.0	38.0	3.2	258.4	608.7
5.00	5.0	150.0	40.0	3.8	362.2	853.3
6.00	6.0	180.0	42.0	4.3	475.2	1119.4
7.00	7.0	930.0	782.0	1.2	1043.9	2459.4
8.00	8.0	1720.0	822.1	2.1	2814.3	6630.2
9.00	9.0	2550.0	862.1	3.0	5256.2	12383.0
10.00	10.0	3420.0	902.2	3.8	8318.3	19597.1
11.00	11.0	4330.0	942.2	4.6	11974.5	28210.6
12.00	12.0	5280.0	982.3	5.4	16210.8	38190.9
13.00	13.0	6270.0	1022.3	6.1	21020.5	49522.0
14.00	14.0	7300.0	1062.4	6.9	26401.3	62198.7
15.00	15.0	8370.0	1102.4	7.6	32354.2	76223.0
16.00	16.0	9480.0	1142.5	8.3	38882.1	91602.2
17.00	17.0	10630.0	1182.5	9.0	45989.7	108347.0
18.00	18.0	11820.0	1222.6	9.7	53682.7	126471.0
19.00	19.0	13050.0	1262.6	10.3	61967.9	145990.1
20.00	20.0	14320.0	1302.7	11.0	70852.6	166921.5
21.00	21.0	15630.0	1342.7	11.6	80344.6	189283.7
22.00	22.0	16980.0	1382.8	12.3	90452.3	213096.3
23.00	23.0	18370.0	1422.8	12.9	101184.3	238379.7
24.00	24.0	19800.0	1462.9	13.5	112549.3	265154.6
25.00	25.0	21270.0	1502.9	14.2	124556.5	293442.3
26.00	26.0	22780.0	1543.0	14.8	137215.2	323264.8

P. 30

STAGE - NORMAL FLOW RELATIONSHIP FOR REACH FROM ASHBY RD. TO SOUHEGAN R.

Before failure the water surface would be 7.0 ft. above the streambed (flow of 2625 cfs). To determine water surface and flow after failure, it is necessary to include attenuation. To do so, we will use the increase in channel area multiplied by the channel length of 3400' to determine storage (see p. 32)

The attenuated peak flow is 15,000 cfs, which yields an elevation of 9.3 ft. above the streambed. There are no dwellings on this reach.

The Souhegan in this area is wide and meandering, with a broad, marshy flood plain. Within 2500 ft. of the juncture with the West Branch, the Souhegan enters Water Loom Pond. The inflow to Water Loom Pond caused by the failure of Souhegan River Watershed Dam #35 would raise the level of Water Loom Pond significantly. Whether this would overtop Water Loom Pond &/or cause it to fail would depend on antecedent water levels at the pond and other factors.

The separate report on Water Loom Pond discusses the possible effects of that dam's failure downstream.

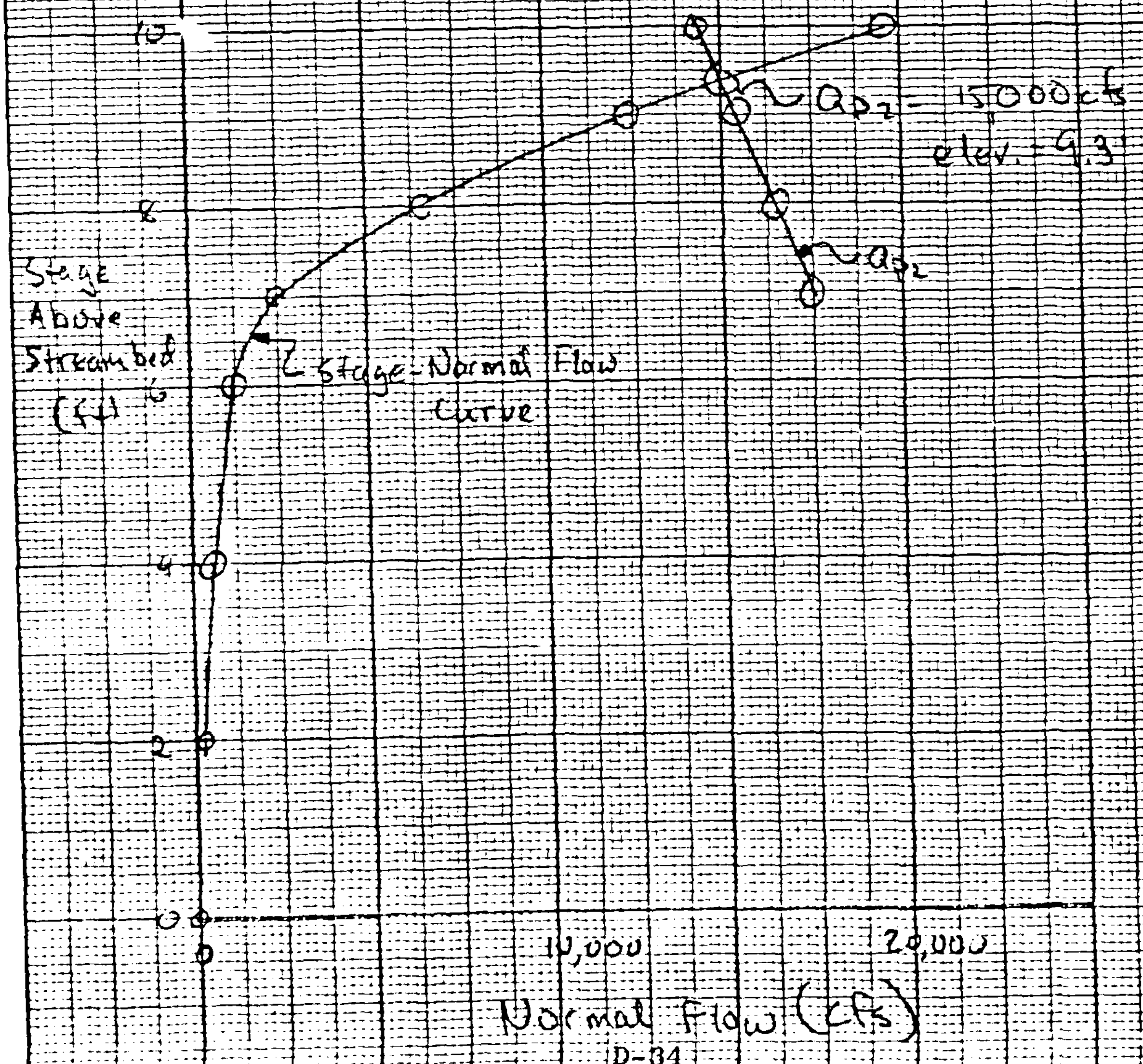
The table on p. 33 summarizes the effects of failure of Souhegan R. W. D. #35.

Attenuated Failure Outflow at the Souhegan TCG 5/31/79 p.32

$$Q_{p_2} = Q_{p_1}\left(1 - \frac{Stor}{1005}\right)$$

$$= 17{,}500\left(1 - \frac{Stor}{1005}\right)$$

elev. (ft)	Area (above 7.0 ft) (ft²)	Storage $\left(\frac{Area \times 3400}{43{,}560}\right)$ (Ac-Ft)	Q_{p_2}
7	0	0	17,500
8	810	62	16,500
9	1620	126	15,400
10	2490	194	14,300



Location Number (see map, p. 6)	Flow Depth Before Failure (ft)	Flow Depth After Failure (ft)	Peak Flow After Attenuation (cfs)	Comments
@ Dam	–	–	26,000	
(1) tailwater, at Binney Hill Rd.	7.3	12.8	26,000	would severely damage or destroy bridge.
(2) Smithville @ Rd.	13.6*	19.9*	22,800	Increases flooding at 2 houses from 1 ft± to 8 ft. At 3rd house from 4 ft to 8 ft. Danger of loss of life. Some flooding to other homes possible.
(3) Lumber yard	8.4	13.5	19,500	Minor flooding (~1-2' ±)
(4) Ashb. Rd. Bridge	6.8	9.5	17,500	damage to bridge, & possibly to house just downstream.
(6) Souhegan Confluence	7.0	9.3	15,000	damage to River Rd. Bridge. Possible damage to Watertown Pond Dam on the Souhegan and d/s structures.

* The flow depth at Smithville is greater than at other locations because of the constrictions caused by Goen Rd. and by the stream's narrowing at this point. These constrictions would create the large depths shown.

Test Flood Analysis

SIZE CLASSIFICATION - Intermediate

HAZARD CLASSIFICATION - HIGH

The hazard potential is HIGH primarily because of the potential for serious economic losses and significant loss of life at Smithville in the event of dam failure. Damage to roads in the area, to Water Loom Pond Dam, and to structures on the Souhegan River is also possible.

Test Flood: PMF

Using the NED COE "Max. Prob. Flood Peak Flow Rates," the upstream drainage area of 6.29 sq. mi. with rolling terrain yield a PMF of 1780 csm.

Peak inflow = 1780 (6.29) = 11,200 cfs.

By contrast, the S.C.S. "free board Hydrograph", which is approximately equivalent to the PMF, has a peak inflow of 17,160 cfs (p. 2-5 of "Hydrologic and Hydraulic Design Calculations")

Since the S.C.S. value was developed using a more precise methodology we will use 17,160 cfs as our peak inflow. The S.C.S. developed a full freeboard hydrograph and routed this inflow through the reservoir. The

peak outflow is 12,670 cfs (p. 6-2, S.C.S. "Hyd. & Hyd. Design") gives a water surface at elevation 1089.9' MSL, 22.9' above the low flow outlet, and .1' below the dam crest. The total storage used is 1704 Ac-ft. (Available storage) from the low flow outlet.

Drawdown Time

According to p. 5-2 of S.C.S. calculations, the drawdown time from the emergency spillway crest to the low flow outlet is 7.8 days. A starting point of 1068' MSL which is reached in 6.2 days, was used for freeboard hydrograph routing calculations.

APPENDIX E

INFORMATION AS CONTAINED IN

THE NATIONAL INVENTORY OF DAMS

IDENTITY NUMBER	DIVISION	STATE	COUNTY	CONGR DIST	STATE	COUNTY	CONGR DIST	NAME	LATITUDE (NORTH)	LONGITUDE (WEST)	REPORT DATE DAY MO YR
NH	135	FED	NH	011	02			SOUHEGAN RIVER WATERSHED DAM NO 35	4244.1	7152.9	29JUN79

POPULAR NAME	NAME OF IMPOUNDMENT
	SMITHVILLE RESERVOIR

REGION BASIN	RIVER OR STREAM	NEAREST DOWNSTREAM CITY - TOWN - VILLAGE	DIST FROM DAM (MI)	POPULATION
01 05	WEST BRANCH SOUHEGAN RIVER	NEW IPSWICH	0	

TYPE OF DAM	YEAR COMPLETED	PURPOSES	STRUCTURAL HEIGHT (FT)	HYDRAULIC HEIGHT (FT)	IMPOUNDING CAPACITIES MAXIMUM (ACRE FT)	IMPOUNDING CAPACITIES NORMAL (ACRE FT)	DIST	OWN	FED R	PRV/FED	SCS A	VER/DATE
RE	1965	SC	34	30	1787	65	NED	N	N	N	B	29JUN79

REMARKS

D/S HAS	SPILLWAY LENGTH	SPILLWAY TYPE	SPILLWAY WIDTH (FT)	MAXIMUM DISCHARGE (FT)	VOLUME OF DAM (CY)	POWER CAPACITY INSTALLED (MW)	POWER CAPACITY PROPOSED (MW)	NO	NAVIGATION LOCKS LENGTH (FT)	WIDTH (FT)	LENGTH (FT)	WIDTH (FT)	LENGTH (FT)	WIDTH (FT)	LENGTH (FT)	WIDTH (FT)
1	1209	U	255	13061	71731											

OWNER	ENGINEERING BY	CONSTRUCTION BY
NH WATER RESOURCES BOARD	USDA SCS	

REGULATORY AGENCY

DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NONE	NONE	NONE	NONE

INSPECTION BY	INSPECTION DATE DAY MO YR	AUTHORITY FOR INSPECTION
GOLDBERG ZOINO DUNNICLIFF + ASSOC	14MAY79	PUBLIC LAW 92-367 8AUG1972

REMARKS